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ABSTRACT

The goal of the Schoolhouse Energy Efficiency Demonstration (SEED) was to assist schools in reducing the impact of the rising cost of energy by defining good energy management programs and by implementing quick-fix, low-cost energy efficiency improvements. Twenty schools in 15 states participated in the demonstration program. This report covers the first year of SEED and is presented in three chapters. The first chapter presents the major findings of the SEED program and gives a profile of each of the 20 selected schools. The second chapter contains an energy audit for students and teachers that can be used in the classroom, and a survey of some successful lesson plans on energy. The last chapter is a technical manual consisting of six major parts and a glossary. The first four parts recount the important experiences from the first year of the SEED program. They are designed as background and information for those engaged in energy conservation activities in schools. The fifth part, the Schoolhouse Energy Audit Checklist, is a guide to conducting an energy audit. It is followed by energy report forms and guides to be used by the auditor in obtaining energy audit information required by the Department of Energy (DOE).
(Author/MLF)

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SEED

SCHOOLHOUSE ENERGY EFFICIENCY DEMONSTRATION

EA 012 37

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SOMETHING SPECIAL FROM SEED

Energy Efficiency for Educators and Students

A Public Service Program
Sponsored by

Tenneco Inc
Public Affairs Department
P.O. Box 2511
Houston, Texas 77001

The following school and education-related organizations encourage and recommend the SEED (Schoolhouse Energy Efficiency Demonstration) Program, sponsored and developed by Tenneco Inc., Houston, Texas:

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Association of School Business Officials
Council for American Private Education
Education Commission of the States
National Association of Elementary School Principals
National Association of Secondary School Principals
National Congress of Parents and Teachers (PTA)
National Education Association
National School Boards Association

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Newark, Delaware	Dr. Carroll W. Biggs, Superintendent New Castle County School District
	Mr. Robert P. Bartley Delaware Energy Office
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INTRODUCTION

Energy became a dominant issue in the United States in the last years of the 1970s. It is likely to continue to occupy center stage for much of the 1980s, influencing social, political, economic and international affairs.

Although the issue is complex, national policy is being developed with two objectives in mind: to assure an adequate supply of energy for the future, and to use existing supplies in the most efficient manner possible.

Tenneco is both a major energy producer and transporter, and a major consumer of energy. Its operating companies are engaged in 7 of the nation's 10 most energy-intensive industries, and have reduced energy consumption by as much as 22 per cent since 1972 through comprehensive energy management programs.

SEED, an acronym for Schoolhouse Energy Efficiency Demonstration, originated with Tenneco's successful corporate energy management program, and the company's desire to share its findings through a public service program for the nation's schools. The goal of SEED was to assist schools in reducing the impact of the rising cost of energy by defining good energy management programs and by implementing quick-fix, low-cost energy efficiency improvements.

This program has shown the value of a real, cooperative partnership between the public and private sector in solving one of the serious problems facing society today. Tenneco and 20 school districts joined hands in helping schools deal effectively with the rising cost of energy. Nine of the nation's top education associations recommended the program. And, much encouragement was given by various State and Federal agencies. Locally, the natural gas and electric utility companies were of great assistance.

The program had two components: technical and public awareness. The technical component consisted of energy audits, conducted by an architect and an engineer working closely with school district personnel. In several schools, a technical workshop was conducted to present fundamentals of energy audits and to describe typical problems and solutions of energy inefficiencies. Audiences for the workshop included personnel from across the school district, as well as people from other public and private institutions.

The public awareness component was designed to encourage citizen support for the local school district's energy management program. Energy management was presented as an issue for those concerned with quality education, not as an engineering term. The general theme was that rising energy costs, if not offset by efficiencies, may have to be paid for with funds taken from classroom programs.

INTRODUCTION

A valuable part of the public awareness component is a 21-minute film, *The Fourth R,* which states the issue and shows an energy audit. Produced with the PTA audience in mind, the film also is being shown to students and professional educators. In addition, a 24-page booklet states the message of the film, and lists a number of opportunities for energy conservation in the typical school.

This report covers the first year of SEED, and is presented in three chapters:

- Summary of SEED, a presentation of the major findings of the SEED program.
- Classroom Guide, consisting of two parts. The first part is an energy audit for students and teachers which can be used in the classroom. The second part is a survey of some successful lesson plans on energy.
- Technical Manual, a presentation of the technical lessons learned from the SEED audits. It also contains data collection forms to be used in conducting energy audits in schools.

This chapter, a Summary of SEED, begins with a compilation of the results of the 20 audits, Table 1. The principal finding of the SEED 20-school study is that the average school can reduce its energy consumption by 48.6 per cent, without the use of expensive capital equipment or exotic technology. To the extent that the selected schools are representative, there is a significant opportunity for school energy conservation.

In the audits, the engineers first identified sources of heat gain and loss and quantified each. This information, averaged for the 20 schools, is presented in the Energy Consumption Profile, Table 2.

The Profile identifies the per cent of heat lost through the most common circumstances, and shows the amount of heat gained from sources other than the furnace. It also breaks out electrical consumption into several categories. This analysis led to identification of low-cost opportunities for energy efficiency. With one or two exceptions, recommendations were limited to off-the-shelf materials and proved procedures.

Table 3 identifies projected savings by activity. This table is the best support for the overall conclusion that energy consumption in the selected schools can be cut nearly in half. Under heating fuel, five of the first six items, other than window insulation, account for more than half the projected savings. This is possible through such inexpensive and interrelated actions as night thermostat setback, tightening of the building envelope and control of excessive air movements.

The balance of the first chapter gives a profile of each of the 20 selected schools.

TABLE 1
SUMMARY OF PROJECTED SAVINGS

	Per Cent of Fuel	Per Cent of Electricity	Per Cent of Total	Payback Period (Months)
East Hartford, Connecticut	41.0	40.0	40.0	4
Newark, Delaware	52.3	23.6	36.3	4
Decatur, Georgia	75.0	16.3	34.4	17
Oak Lawn, Illinois	69.0	32.5	47.2	5
Baltimore, Maryland	58.2	30.5	41.2	19
Lexington, Massachusetts	48.5	34.2	42.3	18
Livonia, Michigan	56.4	24.4	44.0	10
Manchester, New Hampshire	65.4	32.3	48.0	8
Lancaster, New York	53.7	45.2	50.8	12
West Irondequoit, New York	51.5	30.8	45.8	9
Cincinnati, Ohio	63.6	49.1	55.2	13
Bethel Park, Pennsylvania	65.0	31.3	51.3	14
Havertown, Pennsylvania	75.8	64.9	67.6	18
Pawtucket, Rhode Island	75.0	21.0	63.0	9
Garland, Texas	59.5	57.6	58.0	7
Houston, Texas	51.0	44.6	46.3	5
Ft. Belvoir, Virginia	85.0	29.0	60.7	12
Newport News, Virginia	62.5	21.3	43.4	12
Salem, Virginia	58.2	59.8	55.2	21
Racine, Wisconsin	61.8	9.9	41.5	14
AVERAGE	**61.4**	**34.9**	**48.6**	**11.6**

TABLE 2
ENERGY CONSUMPTION PROFILE

Heating Fuel Losses	Per Cent of Loss	Per Cent of Total
Transmission		
Roof	20.6	
Windows and doors	35.6	
Walls	20.4	
Floors	5.6	
		82.2
Ventilation		20.7
Infiltration		
Windows	9.8	
Doors	7.2	
		17.0
Potable hot water		7.6
System losses		2.2
Total heating losses		129.7

Heat Gain From Sources Other Than Heating Fuel	Per Cent of Gain	
Electric Power	15.3	
Occupants	7.2	
Daylight	7.2	
Total heating gains		29.7
Heating losses minus gains		100.0

Allocation of Electric Power Consumption	
Fluorescent lighting	33.8
Incandescent lighting	19.8
Exterior lighting	3.2
Ventilation	11.6
Hydronic pumping	15.3
Refrigeration	2.2
Other kitchen	5.5
Miscellaneous	8.6
Total electric power consumption	**100.0**

TABLE 3
PROJECTED SAVINGS BY ACTIVITY

	Per Cent of Savings	Payback Period (Months)
HEATING FUEL		
Caulk and seal windows, skylights and air conditioning window units	6.4	19
Weatherstrip and deactivate doors	4.9	2.5
Insulate windows and skylights	32.5	24
Reduce fresh air intake	7.3	14
Reduce ventilation rates	8.1	2.7
Tune thermostat system	30.7	3.1
Adjust and modify heating system	6.3	18
Install independent water heaters	2.1	65
Lower hot water temperature	1.7	7.6
ELECTRIC POWER		
Deactivate lights near windows	25.4	4
Use high efficiency fluorescent lamps and ballasts	15.0	4
Replace incandescent lamps	33.6	25
Reduce hydronic flow rate	12.7	20
Reduce ventilation rate	4.7	10
Implement energy saving kitchen procedures	2.0	12
Miscellaneous	6.6	8

John A. Langford Elementary School
East Hartford, Connecticut

Description: The school, constructed in 1972, is a single story structure with 47,337 sq. ft. The foundation is an uninsulated slab-on-grade. However, the roof and walls (of brick and block construction) are insulated. Single glazed windows account for 10% of the 20,146 sq. ft. wall area. The site is sheltered from prevailing winds by deciduous trees and other landscaping materials.

Energy Budget: $40,000 **Gas: $17,100** **Electricity: $23,400**
Prior to the SEED audit, Langford School used 12.4 BTU/sq. ft./degree day. If all recommended energy conservation measures are implemented, the projected consumption rate will be reduced to approximately 4.9 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 300	$ 900
• Reduce fresh air intake on rooftop HVAC units	—	4,000
• Place plexiglass screen under skylight	500	1,000
PROCEDURAL CHANGES		
• Adjust thermostat to 78° for cooling	—	2,000
• Deactivate electric baseboard heaters	—	3,500
• Shut off HVAC on weekends and at night	—	500
• Repair rooftop HVAC units	—	1,500
• Institute housekeeping measures	—	50
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	130	560
• Install multivapor lamps in kitchen and gym	2,500	2,100
• Modify exhaust system in kitchen and gym	2,450	2,600
TOTAL	**$5,880**	**$18,710**

McVey Elementary School
Newark, Delaware

Description: The school, built in 1964 with a small addition in 1969, is a single story "wing" shaped building with 55,000 sq. ft. This "wing" configuration loses 57% more energy than a square with the same floor area. The site is essentially flat and devoid of significant buffering vegetation. However, this school is energy conscious for two-thirds of the windows were insulated.

Energy Budget: $24,269 Gas: $10,773 Electricity: $13,496

Prior to the SEED audit, McVey School used 17.7 BTU/sq. ft./degree day. If the SEED recommendations are implemented, the consumption can be reduced to approximately 9.3 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip and reseat doors	$ 381	$ 661
• Place pegboard over fresh air inlets	490	2,140
• Seal drying racks in classrooms	50	23
PROCEDURAL CHANGES		
• Tune thermostat system	500	3,153
• Deactivate window banks of lamps	715	1,776
• Reduce operating time of ventilators	—	140
• Savings from reduction in system operating time	—	103
• Install Energy Conservation Plaque	20	—
• Institute housekeeping measures	60	332
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	200	200
• Install high frequency fluorescent lamps	83	302
• Lower speed on ventilator fans	100	400
TOTAL	**$2,599**	**$9,230**

Briarlake Elementary School

Decatur, Georgia

Description: The school, built in 1964, is a single story T-shaped building with 32,407 sq. ft. The walls are uninsulated with extensive window area, 39% of the exterior wall. The school is situated on a hill but has enough trees to buffer the building from prevailing winds.

Energy Budget: $18,539 Gas: $5,724 Electricity: $12,815

Prior to the energy audit, Briarlake School used 17.6 BTU/sq. ft./degree day. If the SEED recommendations are implemented, the consumption can be reduced to approximately 4.4 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 606	$ 273
• Caulk and regasket windows	1,900	540
• Place pegboard over fresh air inlets	260	1,211
• Insulate upper portion of windows	4,902	1,501
PROCEDURAL CHANGES		
• Tune thermostat system	600	1,600
• Cease using kiln to heat kitchen	—	60
• Install Energy Conservation Plaque	20	—
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	150	425
• Install high efficiency fluorescent lamps	100	345
• Put water heater on timer	154	350
• Install fresh air inlet for heat pump	300	464
TOTAL	**$8,992**	**$6,769**

Roy L. Clark Elementary School
Oak Lawn, Illinois

Description: The school, built in 1964 with additions in 1967 and 1971, is a single story, L-shaped structure. The foundation is an uninsulated slab-on-grade and totals 46,000 sq. ft. The walls are insulated and are built of brick and block totaling 15,653 sq. ft. with only 7% single glazed windows. The windows are shaded by a 3 ft. overhang. The roof is also well insulated. However, the school site is completely devoid of buffering vegetation.

Energy Budget: $12,012 Gas: $6,012 Electricity: $6,000
If all SEED recommendations are fully implemented, Clark Elementary can reduce its energy consumption as much as 47%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Reduce fresh air intake	$ 280	$2,000
• Insulate upper portion of windows	525	1,870
PROCEDURAL CHANGES		
• Tune thermostat system	260	200
• Deactivate unnecessary lamps	—	1,577
• Adjust back draft dampers	—	15
• Reduce temperature on water heaters	—	75
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	45	245
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	1,637	777
• Install timers on exterior lights	100	400
• Place timers on roof top exhaust fans	500	400
TOTAL	**$3,367**	**$7,559**

Friends School

Baltimore, Maryland

Description: Friends School, the only private school in the SEED study, consists of three buildings constructed in 1931 with an addition to one building in 1974. In addition, there is an auditorium, to which classrooms were added in 1956, and a gym, built in 1937, and expanded in 1966. The buildings are multi-story rectangles and are constructed of brick and stone. The total window area is relatively small, only 22%. The site is hilly with moderate vegetation, including some deciduous trees.

Energy Budget: $69,584 Heating Oil: $26,675 Electricity: $42,909

As a result of the SEED audit, it was determined that fuel oil consumption can be reduced approximately 58%, and electric power, another 30%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 763	$ 1,287
• Recaulk and gasket windows	3,585	1,592
• Place pegboard over fresh air inlets	540	5,234
• Insulate upper portion of windows	10,471	3,568
PROCEDURAL CHANGES		
• Tune thermostat system	500	5,442
• Deactivate window banks of lamps	10,000	2,250
• Shut down boilers when possible	2,500	800
• Savings from reduction in system operating time	—	1,100
• Install Energy Conservation Plaques	100	—
• Institute housekeeping measures	—	210
MODIFY EQUIPMENT		
• Reduce boiler firing rates	750	267
• Reduce hydronic pumping rates	1,650	1,182
• Install multivapor lamps where possible	7,900	4,700
• Install independent water heaters	3,750	817
• Reduce fan speeds on ventilators and exhausts	9,061	5,974
TOTAL	**$51,570**	**$34,423**

Lexington High School

Lexington, Massachusetts

Description: Lexington High, now a complex of buildings, was constructed in 1951. The auditorium, shop wing and new class wing were built in 1955. And, in 1962 the field house, science building and buildings "A" through "F" were added. The total square footage is 312,574. Most of the units are two story and built of brick with varying degrees of insulation and a variety of mechanical and electrical systems. Approximately 60% of the exterior surface is comprised of windows. The surrounding land is relatively flat with little landscaping.

Energy Budget: $146,747 **Fuel Oil: $82,862** **Electricity: $63,884**

Prior to the energy audit, the school complex used 12.5 BTU/sq. ft./degree day. If the SEED recommendations are implemented, the consumption rate may be reduced to as little as 6.4 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 630	$ 1,401
• Seal windows	9,500	3,267
• Reduce fresh air intake	1,600	10,300
• Insulate upper portion of windows	28,825	19,004
PROCEDURAL CHANGES		
• Tune thermostat system	2,000	4,000
• Deactivate window bank of lamps	—	1,500
• Reduce temperature on water heater	—	900
• Shut down boilers where possible	2,500	1,500
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	75	400
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	300	2,300
• Install high efficiency fluorescent lamps	34,864	11,091
• Install multivapor lamps in gym and fieldhouse	13,000	6,913
• Install independent water heaters	1,250	3,627
TOTAL	**$94,564**	**$66,203**

Roosevelt Elementary School

Livonia, Michigan

Description: The school, originally constructed in 1957 with additions in 1959 and 1960, is a single story, multi-wing structure. The foundation is slab-on-grade uninsulated and covers 50,000 sq. ft. The brick and block walls are uninsulated and account for 25,000 sq. ft.; the remaining 33% of wall area is covered by single glazed windows. The site is devoid of landscaping except for grass and low shrubs.

Energy Budget: $19,928 Heating Oil: $12,830 Electricity: $7,098

Prior to the SEED audit, the energy consumption rate for Roosevelt Elementary was 15.9 BTU/sq. ft./degree day. If all SEED recommendations are implemented, this consumption may be reduced as much as 44%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 500	$ 350
• Insulate upper portion of windows	3,700	3,980
PROCEDURAL CHANGES		
• Tune thermostat system	260	65
• Deactivate unnecessary lights	—	306
• Institute boiler night set-back of 50°F	—	2,208
• Keep classroom doors closed	—	130
• Install Energy Conservation Plaques	20	—
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	84	294
• Install multivapor lamps in gym	505	737
• Place circulating pump on timer	1,000	500
• Replace circulating pumps with more efficient type	250	250
TOTAL	**$6,319**	**$8,820**

Hillside Junior High School

Manchester, New Hampshire

Description: The school, constructed in 1965, is a three story structure built on pier-on-beam and slab-on-grade with 116,500 sq. ft. of floor space. A bomb shelter is located under the slab-on-grade portion of the school. The walls are of brick and block cavity construction with only 8.5% window area. Only the roof is insulated. The structure is built into the side of a moderately sloping hill and has no landscaping other than low shrubs.

Energy Budget: $33,961 Heating Oil: $13,878 Electricity: $20,083
This school used only 6.1 BTU/sq. ft./degree day due primarily to the small amount of window area. However, as a result of the energy audit the projected reduction in the rate of energy consumption is 4.1 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Seal unused shop door	$ 5	$ 20
• Place pegboard over fresh air inlets	240	760
• Insulate upper portion of windows	1,640	1,050
• Place dampers on roof-top exhaust	7,000	3,910
PROCEDURAL CHANGES		
• Tune thermostat system	—	3,370
• Deactivate unnecessary classroom lights	—	1,167
• Reduce temperature on water heater	—	140
• Shut down boilers when possible	1,000	300
• Savings due to reduction in system operating time	—	800
• Install Energy Conservation Plaque	200	—
• Institute housekeeping measures	20	104
MODIFY EQUIPMENT		
• Reduce hydronic pumping rates	2,500	2,800
• Install high efficiency fluorescent lamps	154	618
• Install independent water heater	1,250	500
• Place timers on exhaust fans	300	200
TOTAL	**$14,309**	**$15,739**

Court Street Elementary School

Lancaster, New York

Description: The school, constructed in 1955, is a non-symmetrical structure built of brick and block. The foundation is slab-on-grade, uninsulated and totals 47,653 sq. ft. The walls are also uninsulated and cover 26,983 sq. ft., 27% of which is window area. The school site is flat and entirely devoid of landscaping materials.

Energy Budget: $29,809 Gas: $21,057 Electricity: $8,473

The rate of energy consumption in Court Street School prior to the energy audit was 22.3 BTU/sq. ft./degree day. If the SEED recommendations are implemented, the consumption rate can be reduced to approximately 10 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 560	$ 250
• Seal and caulk windows	1,570	1,300
• Reduce fresh air intake on unit ventilator	—	264
• Insulate upper portion of windows	5,803	5,612
PROCEDURAL CHANGES		
• Tune thermostat system	500	2,757
• Deactivate window banks of lamps	—	820
• Reduce temperature on water heater	500	960
• Shut down boilers when possible	3,000	2,000
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	105	460
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	63	204
• Install multivapor lamps in gym	1,000	2,250
TOTAL	**$13,121**	**$16,877**

Iroquois Middle School

West Irondequoit, New York

Description: The school, constructed in 1948 with an addition in 1962, is a three level, T-shaped structure. The basement foundation is an uninsulated slab-on-grade with 24,456 sq. ft. The building has a total floor space of 65,345 sq. ft. The walls are uninsulated and composed of brick and tile totaling 22,478 sq. ft. of which 23% is single glazed, operable windows. The site is surrounded by a residential area with little significant buffering vegetation.

Energy Budget: $21,765 Gas: $11,240 Electricity: $10,525
During the 1977-1978 school year, Iroquois Middle School consumed energy at a rate of 9.2 BTU/sq. ft./degree day. If the SEED recommendations are fully implemented, the consumption rate could be reduced to 5.4 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 350	$ 85
• Seal and caulk windows	92	153
• Insulate upper portion of windows	610	1,890
PROCEDURAL CHANGES		
• Tune thermostat system	460	510
• Deactivate unnecessary lamps	—	1,500
• Deactivate portable freezer when not in use	—	200
• Reduce temperature on water heater	—	60
• Institute housekeeping measures	—	130
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	533	450
• Install multivapor lamps in gym	1,200	528
• Insulate boiler manifold	200	100
• Insulate expansion tank	122	38
• Replace gasket on ice cream freezer	15	50
• Replace kettle	500	320
• Install dampers and timers on rooftop exhaust fans	175	830
TOTAL	**$4,257**	**$6,844**

Cameron Park Elementary School
Cincinnati, Ohio

Description: The school, built in 1965 with a small addition in 1971, consists of two sections, a long narrow two story rectangle and a square one story wing. The building is well insulated except for the slab-on-grade foundation. The school is situated on the crest of a hill and is unbuffered from prevailing winds.

Energy Budget: $14,962 Gas: $6,329 Electricity: $8,633

During the 1977-1978 school year, Cameron Park School consumed 9.1 BTU/sq. ft./degree day of energy for heating. If the SEED recommendations are implemented, the consumption rate may be reduced by as much as 63% to approximately 3.4 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 337	$ 273
• Close skylight louvres at night	—	50
• Reduce area of fresh air inlets	100	200
• Insulate upper portion of windows	3,455	1,323
PROCEDURAL CHANGES		
• Tune thermostat system	500	2,065
• Deactivate window banks of lamps	—	405
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	—	99
MODIFY EQUIPMENT		
• Reduce boiler firing rate	—	200
• Reduce hydronic pumping rate	400	705
• Install high efficiency fluorescent lamps	94	346
• Install multivapor lamps in multipurpose room	4,250	1,026
• Reduce air handler and exhaust fan rates	700	1,755
TOTAL	**$9,856**	**$8,447**

William Penn Elementary School
Bethel Park, Pennsylvania

Description: The school, built in 1961, is essentially a single story square with 24,169 sq. ft. The walls are uninsulated and glazing accounts for 31% of the exterior surface. While a hill near the school provides some buffer from the wind, the site immediately surrounding the building is relatively flat with little landscaping.

Energy Budget: $10,045 Gas: $5,953 Electricity: $4,092
William Penn prior to the energy audit was consuming 8.2 BTU/sq. ft./degree day, well below the average of 13.3 BTU/sq. ft./degree day for most schools. If the SEED recommendations are fully implemented, the consumption rate can be reduced to approximately 5.33 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 20	$ 100
• Double glaze skylights	100	35
• Place pegboard over fresh air inlets	140	380
• Reduce fresh air intake in multipurpose room	190	467
• Insulate upper portion of windows	2,680	1,352
PROCEDURAL CHANGES		
• Tune thermostat system	500	1,188
• Deactivate window banks of lamps	—	400
• Reduce temperature on water heater	500	319
• Shut down boilers when possible	500	300
• Install Energy Conservation Plaque	20	—
• Institute housekeeping measures	55	80
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	150	220
• Install high efficiency fluorescent lamps	80	206
• Install multivapor lamps in gym	1,000	457
TOTAL	**$5,935**	**$5,504**

Lynnewood Elementary School

Havertown, Pennsylvania

Description: The school, constructed in 1950 with an addition in 1967, is a two story multi-sided building with some one story sections. The foundation is an uninsulated slab-on-grade and provides 67,868 sq. ft. of floor space. The walls, built of brick and block cavity, are also uninsulated and cover 32,195 sq. ft. of whjch 46.9% is window area. One side of the school is built into a slope with the other sides completely devoid of landscaping materials.

Energy Budget: $34,116 **Fuel Oil: $22,694** **Electricity: $11,422**

The energy audit defined Lynnewood School's energy consumption at 25 BTU/sq. ft./degree day. If all SEED recommendations are implemented, the consumption can be reduced to approximately 4.2 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 1,000	$ 591
• Seal and/or caulk windows	5,920	6,624
• Place pegboard over fresh air inlets	200	400
• Reduce fresh air intake in gym and auditorium	190	523
• Insulate upper portion of windows	10,500	5,740
PROCEDURAL CHANGES		
• Tune thermostat system	500	2,000
• Reduce temperature on water heaters	—	848
• Shut down boilers where possible	1,000	300
• Install Energy Conservation Plaques	40	—
• Institute housekeeping measures	50	200
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	11,500	5,900
• Install multivapor lamps in gym	1,500	486
• Install independent water heater	1,250	1,060
• Place timers on exhausts	300	200
TOTAL	**$33,950**	**$24,872**

Flora S. Curtis Elementary School
Pawtucket, Rhode Island

Description: The school, constructed in 1955 with additions in 1965, is a single story, I-shaped structure with a slab-on-grade foundation. The building totals 46,000 sq. ft. and has uninsulated brick and block cavity walls. The total wall area is 23,600 sq. ft. of which 34% is single glazed operable windows. The site is completely devoid of buffering landscaping other than some low shrubs.

Energy Budget: $26,250 Heating Oil: $20,250 Electricity: $6,000
During the 1977-1978 school year, Curtis Elementary consumed energy at a rate of 21.5 BTU/sq. ft./degree day. If the SEED recommendations are fully implemented, the rate of energy consumption may be reduced as much as 63%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 100	$ 300
• Caulk and seal windows	100	300
• Replace window gaskets	600	300
• Place pegboard over fresh air inlets	300	3,000
• Insulate upper portion of windows	2,700	3,150
• Double glaze skylights	100	120
PROCEDURAL CHANGES		
• Tune thermostat system	500	5,560
• Deactivate window banks of lamps	—	700
• Deactivate vestibule heater	—	200
• Reduce exhaust fan flow rates	100	160
• Install Energy Conservation Plaques	20	—
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	81	276
• Place timers on rooftop exhaust fans	2,000	1,500
• Reclaim steam trap waste	1,200	600
• Install more efficient steam pumps	600	300
TOTAL	**$8,401**	**$16,466**

Montclair Elementary School

Garland, Texas

Description: The school, constructed in 1968 and retrofitted for air-conditioning in 1973, is a 31,000 sq. ft. single story, U-shaped structure made of brick and clay tile on a slab-on-grade foundation. The total wall area is 12,462 sq. ft. of which 34% is single glazed, operable windows. The windows are shaded by 5-ft. overhangs. The roof is insulated only through use of an acoustical tile ceiling. There was no buffering landscaping.

Energy Budget: $13,161 Gas: $3,483 Electricity: $9,678

If the following recommendations are fully implemented, Montclair Elementary could reduce its energy consumption as much as 58%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Plant a windbreak	$1,200	$ 200
• Install and seal partition plenum	170	2,200
PROCEDURAL CHANGES		
• Turn off heaters at night	—	1,800
• Lower temperature on refrigerator	—	100
• Seal economizer	50	300
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	703	1,673
• Reduce compressor tonnage rating	—	300
• Use high EER compressor	2,100	1,000
• Insulate water heater	40	72
TOTAL	**$4,263**	**$7,645**

T. H. Rogers Junior High School
Houston, Texas

Description: The school, built in 1962 with an addition in 1966 is a campus-like complex, with eight structures connected by open air walkways. The school was retrofitted for air conditioning in 1972. The main building, gym and auditorium are two story while the other buildings are single story. All are built on a slab-on-grade foundation with brick and block walls. The total floor area is 103,305 sq. ft. and the fenestration is excessive. The site is devoid of buffering vegetation.

Energy Budget: $60,159 Gas: $26,488 Electricity: $33,671
If all of the SEED recommendations are implemented, the use of natural gas can be reduced by 51% and the use of electricity can be reduced by 44%.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Turn air handlers off during summer	$ —	$ 1,185
• Reduce air handler flow rates when in operation	900	2,250
• Operate unit ventilators on low speed	75	1,067
PROCEDURAL CHANGES		
• Institute heating and cooling season discipline, including thermostat control	3,500	9,915
• Deactivate window banks of lights	1,800	1,080
• Deactivate unnecessary lights	1,000	2,175
• Install Energy Conservation Plaques	200	—
• Institute housekeeping measures	—	530
MODIFY EQUIPMENT		
• Place heating boilers on outdoor temperature control	1,500	5,352
• Modify chiller system	300	340
• Reduce hydronic flow rates	1,000	3,400
• Use high efficiency fluorescent lamps	376	878
• Repair exterior lighting control	500	225
• Place office air conditioning on timer	500	1,550
TOTAL	**$11,651**	**$29,947**

Markham Elementary School

Fort Belvoir, Virginia

Description: The school, constructed in 1960 with an addition in 1967, is one story, T-shaped building with 36,207 sq. ft. of floor space. The walls are uninsulated and of brick and block construction covering 12,668 sq. ft. of which 47% is window area. The windows are partially shaded by a four-foot overhang. The school is situated near the Potomac River so as to utilize the dense landscaping materials and deciduous trees as a buffer from the elements.

Energy Budget: $12,258 **Fuel Oil: $6,970** **Electricity: $5,288**

Prior to the energy audit, Markham School's energy consumption rate was 18.4 BTU/sq. ft./degree day. If all SEED recommendations are followed, the consumption rate could be reduced to as little as 3.9 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 200	$ 220
• Place pegboard over fresh air inlets	120	300
• Insulate upper portion of windows	2,000	905
• Place dampers on exhaust fans	600	190
PROCEDURAL CHANGES		
• Deactivate window banks of lamps	—	474
• Shut down boilers when possible	5,500	8,522
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	100	120
• Use low paraffin heating oil	200	2,000
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	136	210
TOTAL	**$8,876**	**$12,941**

Hidenwood Elementary School
Newport News, Virginia

Description: The school, built in 1957, is a single story, H-shaped building with a satellite attached to one of the legs of the "H". The building has a total square footage of 53,476. The exterior walls are uninsulated and include 32% glazing, a portion of which is glass brick. The site is flat with no significant buffering vegetation except for low shrubs near the building.

Energy Budget: $22,219 **Fuel Oil: $11,909** **Electricity: $10,309**

Prior to the energy audit, Hidenwood Elementary consumed 19.2 BTU/sq. ft./degree day of energy. If all of the following recommendations are implemented, the rate of consumption may be reduced to 7.2 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 600	$ 600
• Seal and/or caulk windows	1,400	923
• Reduce ventilator fresh air inlet	300	3,000
• Insulate upper portion of windows	2,270	1,420
• Place dampers on rooftop exhausts	124	750
PROCEDURAL CHANGES		
• Tune thermostat system	300	1,561
• Deactivate window banks of lamps	—	500
• Reduce operating time of HVAC system	1,000	538
• Install Energy Conservation Plaque	20	—
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	300	600
• Install high efficiency fluorescent lamps	71	136
TOTAL	**$6,385**	**$10,028**

Oak Grove Elementary School
Salem, Virginia

Description: The school, originally constructed in 1958 with additions in 1963 and 1967, is a single story U-shaped building. The foundation is an uninsulated slab-on-grade and accounts for 46,149 sq. ft. The walls, made of uninsulated concrete block and brick cavity, comprise 27,801 sq. ft. of which 30% is window area. The school is situated such that it takes advantage of dense landscaping, including deciduous trees and the natural contour of the land.

Energy Budget: $15,471 Gas: $10,717 Electricity: $4,754
During the 1977-1978 school year, the building's energy consumption was 17.7 BTU/sq. ft./degree day. After the SEED recommendations are implemented the energy consumption may be reduced to 7.4 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 477	$ 135
• Reduce ventilation by restricting fresh air inlets	—	597
• Insulate upper portion of windows	5,000	4,291
PROCEDURAL CHANGES		
• Tune thermostat system	500	1,937
• Deactivate unnecessary lamps	—	80
• Reduce temperature on water heaters	300	260
• Shut down boilers where possible	800	540
• Install Energy Conservation Plaques	20	—
• Institute housekeeping measures	—	230
MODIFY EQUIPMENT		
• Reduce hydronic pumping rate	470	693
• Install high efficiency fluorescent lamps	3,520	1,711
• Install multivapor for exterior lighting	900	280
• Install independent water heater	1,250	70
TOTAL	**$13,237**	**$10,824**

Starbuck Junior High School
Racine, Wisconsin

Description: The school, built in 1961, is roughly a rectangular structure with one and two story sections. The two story section forms a narrow wing. The total floor area is 120,000 sq. ft. Single glazed windows made up 26% of the wall area. The site is bare and completely devoid of buffering vegetation.

Energy Budget: $48,965 Gas: $29,819 Electricity: $19,146

During the 1977-1978 school year, Starbuck consumed energy at the rate of 13.1 BTU/sq. ft./degree day. If the SEED recommendations are fully implemented, the consumption rate may be reduced to approximately 5.0 BTU/sq. ft./degree day.

Recommendations	Cost	Annual Savings
TIGHTEN THE BUILDING ENVELOPE		
• Weatherstrip doors	$ 36	$ 230
• Reduce ventilation by restricting fresh air inlets	930	5,000
• Insulate upper portion of windows	16,488	8,871
PROCEDURAL CHANGES		
• Tune thermostat system	1,000	7,000
• Deactivate window banks of lights	—	1,800
• Reduce temperature on water heaters	500	720
• Install Energy Conservation Plaques	20	—
MODIFY EQUIPMENT		
• Install high efficiency fluorescent lamps	213	586
• Install multivapor lamps in gym	3,200	1,250
TOTAL	**$22,387**	**$25,457**

SCHOOLHOUSE AS AN ENERGY CONSERVATION LABORATORY
A TEACHER WORKBOOK

Introduction

Rarely in the history of modern education has an educational tool been so appropriate or so relevant as is the schoolhouse to the teaching of energy education; and never has there been a laboratory specimen, the schoolhouse, so obviously in need of attention. In the rush of playing "catch-up" during the baby boom of the 1950's and 60's, this nation's schools sacrificed energy efficiency for space. Energy was cheap in those decades and providing more classroom space was essential. The walls of glass, the banks of lights, the over-sized equipment, and the rapid construction during that period are now millstones around the necks of school districts.

The past cannot be changed, but the present and future can! All occupants in the schoolhouse can take interest and responsibility for more energy efficiency. Administrators, teachers, staff personnel, and students can pivot the axis toward accountable, judicious energy usage.

The Magic of Energy Surveys

Students can develop an energy awareness and some expertise in the field of energy conservation. Students, with professional guidance, can perform an energy survey and follow-up analysis. This expertise can be shared with all in the school to create a unified commitment to energy efficiency.

For the uninitiated, an energy survey is a physical tour of a building to determine how the building utilizes energy. The survey, if done well, identifies energy saving opportunities and suggests methods to accomplish each one. This information is recorded and the results analyzed for possible corrective action. The word survey is used deliberately here to distinguish the suggested student activity from an energy audit, a more technical analysis of a building's energy usage.

Involving the students in a schoolhouse energy conservation program can produce positive results. One school district in Wyoming assigned students and staff to every building energy team. Together they reduced the electrical bill by 50% in one year. In a Colorado district, the eighth grade curriculum requires every science student to participate in a school energy audit. Student participation, awareness and cooperation can help reduce energy usage. The dramatic results have an observable and measurable positive effect on the school climate. There is a "little magic" in saving, perhaps this is why we are a nation of collectors. Energy conservation can utilize this touch of magic.

Developing an energy ethic together can provide a school community with a real opportunity for caring, sharing, and learning. And this is what education is all about!

A TEACHER WORKBOOK

In The Beginning

Student research in energy conservation, as in any other subject, is a good place to start. Although the grade level is a consideration, the methods and materials presented here can be modified for use from grades 6 through 12. Begin by inviting an architect, mechanical engineer or representative of your local utility company to speak to the class. Senior citizens, knowledgeable in energy management make excellent consultants. A letter or trip to the State Energy Conservation Office or Department of Energy will generate numerous pieces of literature on energy conservation, useful not only in the school but also at home. During this research period it is also a good time to show the Schoolhouse Energy Efficiency Demonstration film *The Fourth R*. Although the film is intended for older audiences, it displays a mini-audit in a brief, concise way that has been effective with intermediate, middle and high school students.

Conducting The Survey

Before conducting an energy survey, review with students the set of questions and activities in Section Two. Ask each student to respond to the questions during and after the energy tour. It is wise, therefore, to ask the students to carry the survey forms on the tour for quick reference and review.

The teacher is encouraged to have the building tour conducted by a knowledgeable energy "expert" (from the local school district, utility, or community) who is familiar with the building. The teacher and/or "expert" should carry a set of master keys to open doors to the many areas they will visit and to have the route carefully planned in advance. Light meters and mercury thermometers are also essential. Allow time on the tour for questions. Encourage the custodian to join the tour so that he feels part of the "team".

A reasonable place to start any energy audit is on the outside of the building. Many students pass through the entrance portals of their schools without really noticing the building structure. This survey is an ideal opportunity to sharpen their awareness of a part of the world where they spend a significant portion of their lives.

As the class proceeds inside the building, a new world of energy awareness for students should emerge. The most noticeable observations will be the temperature change and the lights.

As the class proceeds through the building, students will become alert to areas affecting instruction they may have never noticed. After spending a few minutes in the cafeteria kitchen, the boiler/furnace room, and other unique areas of the school not usually available to them, students grasp the complexity of the educational system and expand their energy usage awareness and knowledge.

After the energy survey has been completed, the class should have many unanswered questions. The teacher can request an energy "expert" to answer these questions, or suggest that the students do team research to secure answers. Discussion and projects stimulate commitment to effect responsible energy usage.

After The Tour

After the students have returned to the classroom and the survey form is filled out, this is the time to review or "debrief". The resource person can respond to questions, analyze results, and discuss possible energy conservation options.

The class can then prepare a report for the principal or energy team. This report can be presented in written form or orally.

Going Beyond The Survey

In those classes with exceptionally alert students, a successful activity has involved the design of an energy efficient schoolhouse. A reinforcement of the learning activity follows when an architect or engineer analyzes the plans for the class.

Other activites that can extend the use of the school as an energy conservation laboratory are:

- Suggest students research the addition of a solar heating system to the school to discover if it is practical and efficient.
- Have students develop check lists to grade members of the student body and staff on energy management habits.
- Have the students design reminders to aid occupants in turning off lights.
- Have student teams read the electric or natural gas meters twice a day to record usage. A two week experiment will indicate how much is used days, nights, and weekends. It is suggested an expert explain how meters are read.
- Assign a group of students to research and report on what their classroom, clothes, and school activities would be like if they lived in the early 1900's. Another group could do life in the year 2010 A.D. Relate how energy usage affects standards of living.
- Have students secure copies of utility bills for the school and graph usage patterns over the past two years on a monthly basis. Students could graph costs for this period and display findings in a busy hallway or other areas where they will be easily observed.

Additional activities will emerge as you proceed through the energy unit, both through your imagination and the students' enthusiasm.

Tips For The Teacher — Things To Observe While On The Tour

(Keyed to Student Survey Form)

I. A Look At The School From Outside

A. When starting the energy survey outside the building note the configuration of the building. Is it shaped like an *E, H, T,* rectangle, square, etc?

B. What direction does the front of the building face? What direction do major entrances face? Which way does the prevailing wind blow? Does the building have any protection against prevailing winds, such as trees, or does it need any?

C. Note approximate percentage of walls that windows occupy. What direction do windows face? Are the windows tight-fitting? Can these windows be opened? If they can, are they open during heating/cooling seasons?

D. Could the windows be double-paned or replaced by insulated walls? How would this affect internal illumination patterns? Note any cracked or broken windows. Plastic windows have the same heat loss as glass windows.

E. Do the exterior doors seal tightly? Note if they are out of alignment or close too slowly. Should double or vestibule doors be installed? What is the temperature difference between outside and inside, and what does this mean to the group? When doors are open is there a "wind tunnel" effect in the halls?

F. Are the exterior walls in good condition and do their colors affect energy usage?

G. What about the security lights — are they effective? Do they actually reduce vandalism? What would happen if they were all turned out? Note what time they go on. Off.

II. A Look Inside The School

H. When the students proceed inside, have them record light levels using a light meter, and note temperature levels using a mercury or digital thermometer. (Be sure body heat is not allowed to affect readings.) Light readings are more realistic if made at desk-top level. It is not necessary to visit every area of the building. It is wise to select representative samples of classrooms, rest rooms, etc., and observe other areas from hallways.

I. Be sure students note which lights are unnecessary or too bright. Also look for energy waste where lights are on in unoccupied areas. Discuss how the colors of the walls affect light levels. Students could calculate how much energy would be saved if energy-saving fluorescent tubes (35 watt) were placed throughout the school. If fluorescent lamps have been removed, have students check to see if the ballasts are disconnected. Ask why this is important.

J. Students will be interested in knowing if the light switches are conveniently located and used. Remind students to observe how the natural light is utilized. Does the use of window shades optimize the use of natural light?

K. Ask the students' opinion concerning skylights and if they are wisely used. Are the lights, fixtures, and skylights clean? Discuss how much dirty windows, fixtures and lamps affect natural lighting.

III. Cafeteria/Kitchen

L. When visiting the kitchen area, have the students ask the head cook about pre-heating practices, baking schedules, and the types of energy-using equipment necessary to produce the meals.

IV. Exhaust Fans

Have students count exhaust fans as they tour the building. Check Industrial Arts area, kitchens, rest rooms, auditoriums, etc. Note the size, operating times, and methods of fan control.

V. Hot Water For Washing

Note if water faucets drip or have excessive pressure. Students can consider if water restricters would reduce waste. What hot water temperature is required by the local health code/the Federal government? How is the water heated?

VI. Heating/Cooling System

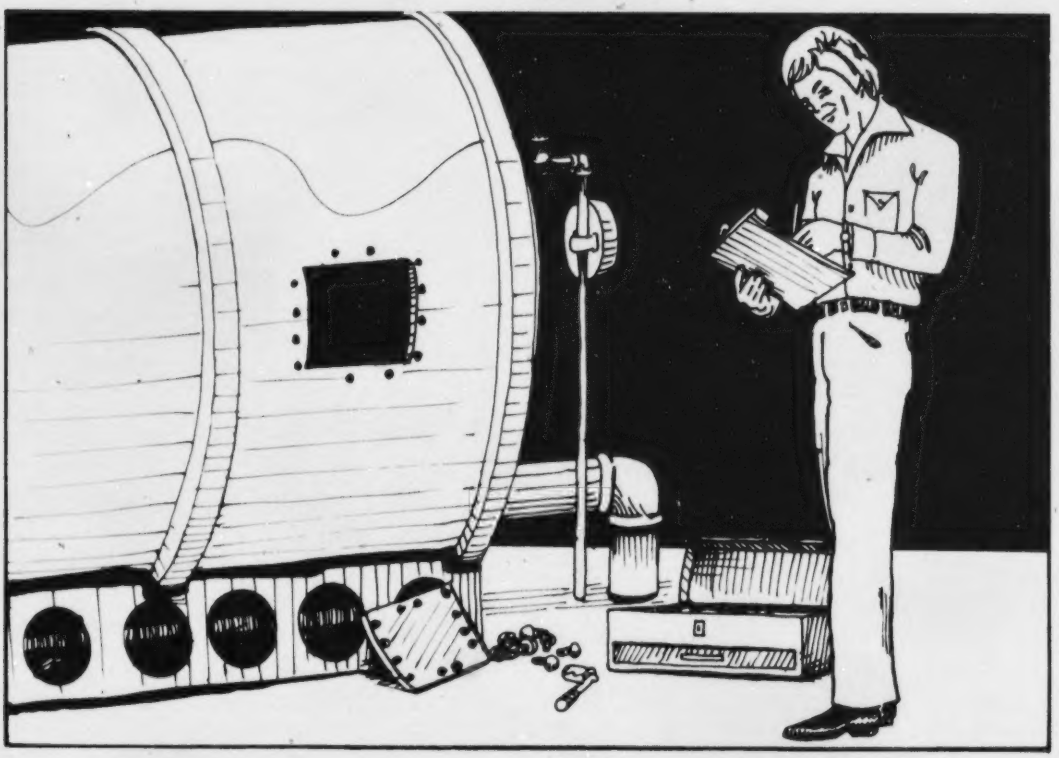
How does the heating/cooling get to the classroom or hallway? Have students note if the vent or heating element appear clean and unblocked. They will want to know how the return air gets to the heating source and if there is air movement in the area. Have students judge if the thermostats are properly located and controlling the environments. Are these thermostats too easily "adjusted" by unauthorized persons?

VII. Control Room

Visiting the boiler/furnace room and listening to an explanation/demonstration of how systems work can be very informative. Have the custodian demonstrate the role of time clocks, the night set-back system, and the control features that make the heating/cooling unit(s) operate more efficiently. Request that students always be alert for cleanliness. Dirt is an insulator, but not a desirable one.

STUDENT SCHOOLHOUSE ENERGY SURVEY

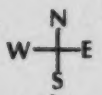
Student's Name _____ Grade Level _____ Room Number ____
School _____ Number of Students _____
Length of School Day _____ Hours for Cleaning _____
Monthly Heating/Cooling Costs _____



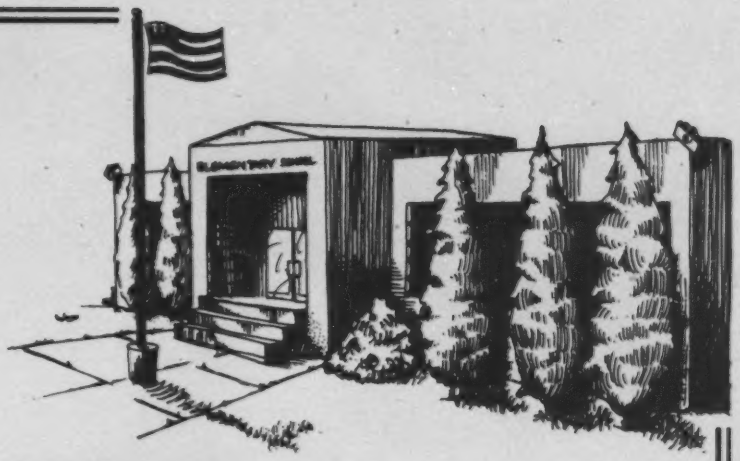
Outside

I. A Look At The School From Outside

A. Draw an outline of the school in the space below.



School Outline



B. What direction does the school entrance face? _____
Which way does the wind usually blow? _____
What protection does the building have? _____

C. Does the school have many windows? Many Some Few
What percent of the wall area is windows? _____ %
How many windows face South? _____ North? _____ East? _____ West? _____
Can the windows be opened? _____ Are the windows tight fitting? _____
Should any windows be double paned? _____ Where? _____

D. Could energy be saved by replacing selected windows with insulated walls or insulating material? _____ Where? _____
Are any window cracked or broken? _____ How many? _____

E. Do the outside doors fit tightly? _____
Do doors need weather stripping? _____
Should there be double doors at any of the entrances? _____

F. Are the outside walls in good condition? _____
Of what material are the outside walls made? _____
Is there insulation in the walls? _____ Roof? _____
How does the color of the walls or roof affect energy usage? _____
_____

G. Is the security lighting effective in preventing vandalism? _____
How many hours are these outside lights turned on? _____

Inside

II. A Look Inside The School

H. Note the following for each area listed below:

Area	Color of Walls	Lighting level in Footcandles	Type of Lighting Incandescent	Fluorescent	Other	Temperature
Halls						
Offices						
Classrooms						
Gym						
Cafeteria						
Library						
Other						

How does the color of the walls affect lighting? _____

_____

I. List any areas of the school where there are unnecessary lights: _____

_____

List any rooms where the lights appear too bright: _____

_____

List any areas where lights appear too dim: _____

_____

Does the school use energy-efficient fluorescent lamps? _____

Mercury vapor? _____ Other? _____

If fluorescent lamps have been removed, are the energy using ballasts disconnected? ___

J. Are there areas where lights have been left on when no one was present? _____

List: _____

Are the light switches located for easy use? _____

Is the natural light from windows used properly? _____

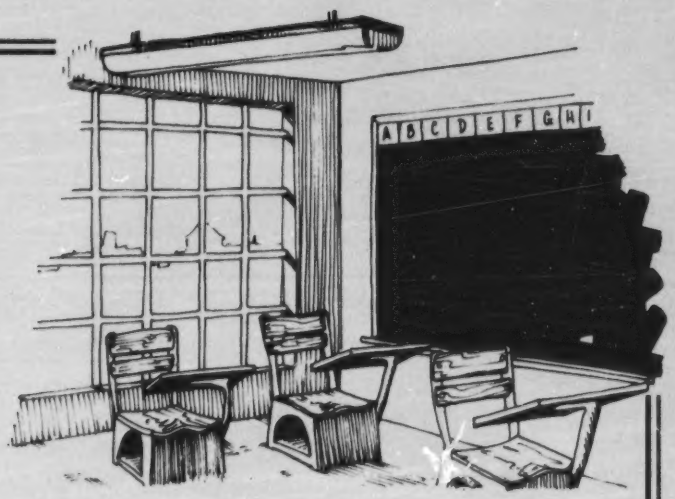
K. How does keeping the following clean affect energy usage?

Windows _____

Light Fixtures _____

Skylights _____

41



III. Cafeteria/Kitchen

L. What energy sources are used in the kitchen:

Natural gas _____

Electric _____

Other _____

List kitchen items using energy (not human) and hours they are used:

Item	Hours Used

Is the kitchen well-arranged to use energy efficiently? _____

Is heat producing equipment located next to cooling equipment? _____

IV. Exhaust Fans

Check the hours exhaust fans operate in the following areas:

Rest rooms _____ Kitchen _____ Art _____

Industrial Art _____ Other _____

How are most exhaust fans controlled? _____

Inside

V. Hot Water For Washing

What is the temperature of the hot water as it comes from the tap in:

Rest rooms	____°F	(____°C)	
Cafeteria/Kitchen	____°F	(____°C)	C°=5/9 (F−32)
Dishwasher	____°F	(____°C)	F°=9/5 (C+32)
Swimming pool	____°F	(____°C)	

Do any faucets drip? _____ Where? _____

Measure the gallons per minute from a faucet _____

How many BTU's are used per hour by the water heater? _____

If electricity is used to heat water, does the heater only turn on at night? _____

VI. Heating/Cooling System

Do the thermostats read/control the room temperature accurately? _____

Are the thermostats well placed? _____

What is the night thermostat setting? _____°F (_____°C)

What are the day settings of thermostats? _____°F (_____°C)

Is there good air movement from the heating/cooling equipment? _____
Is untreated outside air used for cooling when possible? _____
Are the heating/cooling elements kept clean? _____
Do the little used areas have lower themostat settings for heating? _____

VII. Heating Control Room

If the school is heated by a boiler or furnace, what are the BTU's used per hour? _____
Does the heating unit(s) appear clean and well maintained? _____
When was the last time the flame/air settings had an efficiency check?
_____ Is it posted? _____
Is the time clock on the right day and time? _____
What hours does the time clock allow the heating system to operate on day setting? _____
Night setting? _____
What fuel is used to heat the school? _____

VIII. Putting It All Together

After surveying the school and answering the above questions, it is time to look at what you have discovered.

(1) Please list good energy management practices that have already been implemented in the school:

(2) Please list places you observed energy being wasted. Also state a possible solution for each item observed.

SURVEY OF ENERGY EDUCATION PROGRAMS
ENERGY RIDDLES AND JOKES

Source: Beverly F. Wu
Lakeview School
Oakland, California

Class: Language Arts
Grades: 1-3
Time: 2 weeks to 3 months

Concept: The study of energy can be educational and entertaining.
Objective: To teach students about energy and energy conservation using jokes and riddles.
Materials: Several joke and riddle books
Paper, pencil, crayons

Procedure:

1. Begin unit by studying joke and riddle books, which are popular with your class, in your classroom library.
2. Have children bring joke books from the library and their homes to share with the class.
3. Each time a child discovers an energy related joke or riddle, have the child share it with the class.
4. Write down the joke or riddle and give credit to the child who found it. The same child might also illustrate the joke or riddle in the finished book.
5. Encourage children to be creative in finding jokes. Have them ask friends and family members. Suggest they look in the newspapers and magazines. Have some children make up their own energy related humor.
6. Determine with your class the number of riddles and jokes you want in your finished book. Selecting a title for the book may influence the number you determine.
7. Suggested criteria for riddles and jokes for your finished book might include:
   - relating to an energy source;
   - relating to an energy user;
   - using energy as a related word;
   - referring to an energy source or an energy user; or,
   - referring to an energy saver.
8. Take field trips to oil refineries, salt flats, environmental living projects, and utility companies to add stimulation and interest to the project.
9. Let the book be a natural outgrowth of your studies on energy and of your students' personalities.
10. Have each child contribute to the book either by finding a joke or riddle or doing an illustration.
11. Display the finished book at a science or energy fair and at Parents' Night at your school.

CONTROLLING RATE OF CONSUMPTION OF COAL

Source: Sylvia Sather
Whiteman Elementary School
Denver Public Schools
Denver, Colorado

Class: Science
Social Studies
Mathematics
Grades: 1-3
Time: 30 minutes

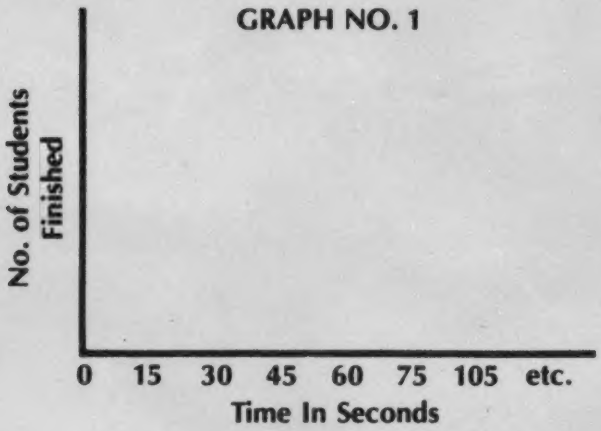
Concept: Resources will be available for a longer period of time if we control the rate of consumption.

Objective: To analyze the effects of conservation compared to unlimited consumption.

Materials: Two chocolate chip cookies per child
Clock or timing device
Chalkboard for timegraphs

Procedure:

1. Each child is given a cookie.
2. When the signal is given the children will begin eating the cookie. They MUST raise a hand when they finish. Count the hands that are raised every 15 seconds until all cookies are consumed. At the last count all hands should be raised. Once the child raises his/her hand, he/she must keep it up.
3. Create the graph. Indicate how many students are finished eating every 15 seconds.



CONTROLLING RATE OF CONSUMPTION OF COAL

Procedure:

4. Talk (analyze) with the students about the interpretations. One cookie equals one coal deposit.
   a. After 15 seconds how many coal deposits were consumed?
   b. After 30 seconds how many?
   c. After 45 seconds how many?
   d. After 60 seconds, 75 seconds, 90 seconds, etc.?
5. Distribute the second cookie. This time children can only take a bite when you say, "Take a bite" (every 15 seconds). The system is the same — the student raises a hand when finished and you tally every 15 seconds.
6. Construct Graph No. 2 (same format)
   This graph usually indicates that coal resources last longer.
7. Analyze the data. How long did it take for all resources to be eliminated?
8. Compare Graph No. 1 (unlimited consumption) to Graph No. 2 (limited consumption). How do the results differ? What is the same? When interpreting data, have 10 seconds equal 10 or 100 years. For example: If Graph No. 2 lasted 30 seconds longer when consumption was controlled, 30 seconds $\times$ 10 = 300 years. Then go into implications for actual coal deposits and rates of consumption.
9. Using divergent questioning techniques
   a. Tell why you think coal was consumed at different rates.
   b. How did we control the rate of consumption on our second experience?
   c. Does this have any implications for us as we use coal, electricity and natural gas?
   d. Can we help control how rapidly we use resources?
   e. Give your own ideas as to how we can do this.
10. The lesson can be enhanced by expanding it as a result of student and teacher brainstorming.

THE SHORT TRIP

Source: *Citizen Action Guide to Energy Conservation,* Citizen's Advisory Committee on Environmental Quality, 1700 Pennsylvania Avenue, N.W., Washington, D.C. 20006

Class: Social Studies or Mathematics
Grades: 4-6
Time: 30 minutes

Concept: If Americans cut down on the use of their automobiles, less gasoline will be needed.

Objective: To determine how families could combine short trips figuring the number of miles saved weekly and yearly.

Materials: None

Background: Americans like to use their automobiles. In fact, 54 per cent of all car trips in this country are less than five miles. Doesn't that seem unnecessary when frequently we could use public transportation, a bicycle, or walk? Interestingly enough — traveling on family business — going to the doctor or dentist or going shopping — accounts for 31.4 per cent of all passenger car trips and averages 5.5 miles one way.

What would happen if each family took one less trip a week, for example, seven instead of eight. By planning ahead to combine errands and appointments, an average family can save $74 a year. This may not be impressive enough on a family scale to some, but if every family did this we would save nationwide:

- 38 billion miles of driving;
- 2.9 billion gallons of gasoline; and,
- more than $1.5 billion.

Procedure:

1. Review with the class the background material above.
2. Ask each student to make a list of typical short trip "destinations" his family makes in an average week.
3. Ask students to give reasons for the excessive number of short trips taken per week by his family.
4. Each student should then plan a daily "trip schedule" which conveniently combines many of the short trips into a few consolidated excursions.
5. Assuming an average of 11 miles (round trip) per short trip, how many miles could be saved in one week? In one year?

DRAGGING SUITCASES

Source: *Computations About The Sources And Conservation Of Energy,* Florida State Energy Office, Tallahassee, Florida

Class: Science or Mathematics
Grades: 4-6
Time: 20 minutes

Concept: To conserve energy, it is evident that one must accomplish a task with the minimum amount of work. In the process of doing work, the less resistance, drag or friction one must work against, the less energy is expended.

Objective: To study the effects of friction/resistance to movement.

Materials: Chalkboard and chalk

Procedure:

1. Copy the following problem on the chalkboard.
   Suppose a car averages 25 miles per gallon of gasoline on long trips when the suitcases are on a luggage rack on top of the car. By putting the luggage in the car (reducing air friction) you get 8% better mileage.
2. Using a map of your state, figure the number of miles from a city on the west side to a city on the east side.
   a. Compute the number of miles per gallon the car would gain with the luggage in the car.
   b. Compute the number of gallons, to the nearest tenth, used in traveling with the luggage: 1) on top of the car, 2) in the car.
   c. Assuming a cost of 95¢ per gallon for gasoline, determine the money saved on the trip by packing the luggage in the car instead of on the roof.

TANGLED IN THE ENERGY WEB

Source: Education Information Associates
Littleton, Colorado

Class: Social Studies or Science
Grades: 4-6
Time: 1 class period

Concept: Many aspects of our lifestyle have become dependent upon nonrenewable fossil fuel supplies.

Objective: To teach the students the effects of the depletion of fossil fuel reserves on our lifestyles.

Materials:
Copy of President Carter's April 20, 1977 energy address
Various lengths of yarn or string
Paper for name tags
Felt-tip markers or crayons

Procedure:

1. On April 20, 1977, President Carter, in his energy address made several references to "the good life". Ask students what this expression means to them.
2. Have students brainstorm those aspects — products, services, necessities — important to "the good life" which affect the American lifestyle.
3. With the students' help consolidate elements until the total equals the number of students in your class. Assign each student to play the "role" of one good life element. Make a "name tag" for each student. You may wish to make one for yourself which reads "Government".
4. Have students stand in a circle. Using lengths of yarn connect elements of the good life to others upon which they may depend. A web of interdependencies will form. Nearly all of the elements are subject to governmental control, and, if you are standing in the middle of the circle, you will become hopelessly entangled.
5. Simulate a production crisis of the fossil fuels by asking those students to carefully remove their strings from other elements which depend on them. The result is a near collapse of the web.
6. Many aspects of "the good life" face potential collapse when fossil fuels are removed. Discuss how society is weakened when almost totally dependent on one element — fossil fuels. Discuss how society can be strengthened by a diversity of energy sources. What are some of the possibilities?

RENEWING FOSSIL FUELS

Source: *Our World of Energy Activities Booklet*
Energy Education Advisory Council,
Philadelphia Electric Company,
Philadelphia, Pennsylvania

Class: Science
Grades: 4-6
Time: 2 class periods

Concept: Energy sources are both renewable and nonrenewable.

Objective: To teach students to distinguish between renewable and nonrenewable energy sources, including the meaning of recycling energy.

Materials: Pieces of natural fibers used in clothing
Synthetic materials used in clothing

Procedure:

1. Introduce the word renewable.
2. Ask students which parts of their bodies are renewable. (They might suggest hair, fingernails, skin, blood cells.)
3. Ask students for suggestions of parts of their bodies which are not renewable. (Responses might include a finger, permanent teeth, tonsils, and appendix.)
4. Remembering what is renewable on the body, have students name some renewable materials from which clothing is made. Show students some of the renewable fibers or fabrics (cotton and wool).
5. Have students examine the clothing they are wearing and see if they can discover some examples of nonrenewable fabrics. Some possibilities include nylon, orlon, rayon, plastics (as in buttons and zippers), and polyesters.
6. Have students bring materials or objects for classification as renewable or nonrenewable.
8. Having established what is meant by renewable and nonrenewable, point out that these terms also apply to energy sources.
9. Have the class list energy sources on the board and decide wich belong in each of the two categories, renewable or nonrenewable.

HOW QUICKLY DOES IT COOL?

Source: *Energy In The Classroom*
Virginia Energy Office
Richmond, Virginia

Class: Science
Grades: 5-9
Time: 30 minutes

Concept: Heat lost by conduction is directly proportional to a temperature difference (the driving force) and inversely proportional to the thermal resistance of the insulating medium.

Objective: To teach students how thermal insulation reduces heat loss.

Materials:
Small box
Thermometer
Insulating materials
Chalkboard

Procedure:
1. Place a thermometer in a glass of hot water or coffee. Read the temperature every five minutes.
2. Have students help make a graph of temperature vs. time on the chalkboard. Now, put a fresh glass of hot water or coffee inside a box and pack cotton balls, fiberglass insulation, or crumpled paper around it.
3. Make a graph of temperature against time as before and compare with the previous case; the effects of the insulation will be obvious.
4. If time permits, have students "invent" their own insulation material. Repeat step 3.

DON'T BE A BIG DRIP — SAVE LITTLE ONES

Source: Northern Colorado Board of Cooperative Services, Longmont, Colorado

Class: Mathematics or Science
Grades: 6-8
Time: 2 class periods

Concept: A relationship exists between awareness of energy sources and the conservation of energy.

Objective: To increase awareness of energy wasted by computing liquid volume using multiplication and division skills.

Materials:
8 ounce glass or plastic measuring cup
Pencil and paper
Leaky faucet
Clock

Procedure:

1. Place measuring cup under a dripping hot water faucet and collect 15 minutes of drips.
2. Compute how much energy was wasted.
   a. Multiply number of ounces of water by 4
      Example: 4 oz. x 4 = 16 oz. per hour
   b. Multiply answer in (a) by 24
      Example: 16 oz x 24 = 384 oz. per day
   c. Multiply answer in (b) by 365
      Example: 384 oz. per day x 365 = 140,160 oz. per year
   d. Divide answer (c) by 128
      Example: 140,160 oz. per year ÷ 128 = 1,095 gallons per year
   e. For oil fired hot water heater — divide answer (d) by 110, which gives the approximate number of gallons of oil wasted.
      Example: 1,095 ÷ 110 = 9.95 gallons of oil per year
   f. For gas fired hot water heater — divide answer (d) by 0.84, which gives the approximate number of cubic feet of gas wasted.
      Example: 1,095 ÷ 0.84 = 1,304 cubic feet of gas per year
   g. For electric hot water heater, multiply answer (d) by 0.25, which gives the approximate number of kilowatt hours of electricity wasted.
      Example, 1,095 × 0.25 = 274 kilowatt hours

THE TROUBLE WITH EXPONENTIAL GROWTH

Source: *Energy and Earth*
The Jefferson County Public Schools,
Jefferson County, Colorado

Class: Social Studies or Mathematics
Grades: 7-12
Time: 1 class period

Concept: Exponential growth is geometic growth (on a pattern, for example, of 1, 2, 4, 8, 16), rather than arithmetic growth (on a pattern of 1, 2, 3, 4, 5). Exponential growth is growth at a fixed percentage rate over a period of time (savings account at compound interest is a standard illustration).

Objective: To explore how consumption of energy coupled with exponential growth leads to depletion of energy resources.

Materials: Checkerboard for each student
Five pounds of rice

Background: To understand the implications of exponential growth in population, in resource consumption or in pollution levels, calculate the doubling time of a growing quantity. A handy rule of thumb is to divide the per cent rate of such growth into the number 70 to arrive at the doubling time. For example, the population of the world, now roughly four billion persons, is growing at about 1.6 per cent per year. The doubling time is 70 divided by 1.6, or 44 years. So long as that rate of growth holds constant, we can calculate the future population as follows:

4 billion people in 1975
- plus 44 years..... 8 billion people in 2019
- plus 44 years..... 16 billion people in 2063

To say this another way, a child born in 1975 who lives 88 years will experience first hand what it is like to live in a world of 16 billion persons or will witness first hand what it was that intervened to forestall the 16 billion.

The U.S. growth rate for electric consumption is illustrative. For much of the 20th century, it has been 7 per cent a year, doubling each decade ($70 \div 7 = 10$). This meant that, besides replacing obsolete facilities, utilities have had to double their usable generating capacity each ten years. Plotting this progression on a simple graph would give a visual idea of the impact of such growth, if it were to continue for two more doubling times from 1970. In fact, many industry experts were predicting just such a growth rate, but since the embargo, consumption has moderated; the industry now projects somewhat slowed rates of growth.

This moderation in growth rate may also be illustrative of a general slowdown both of U.S. population growth and of growth in energy use. It is wise to keep in mind, however, that even lesser growth rates are exponential — that is, they do lead to doublings, even though the doubling time is lengthened.

The following exercise illustrates the arithmetic of doubling, exponential growth, and suggests there are limits to exponential growth of any quantity.

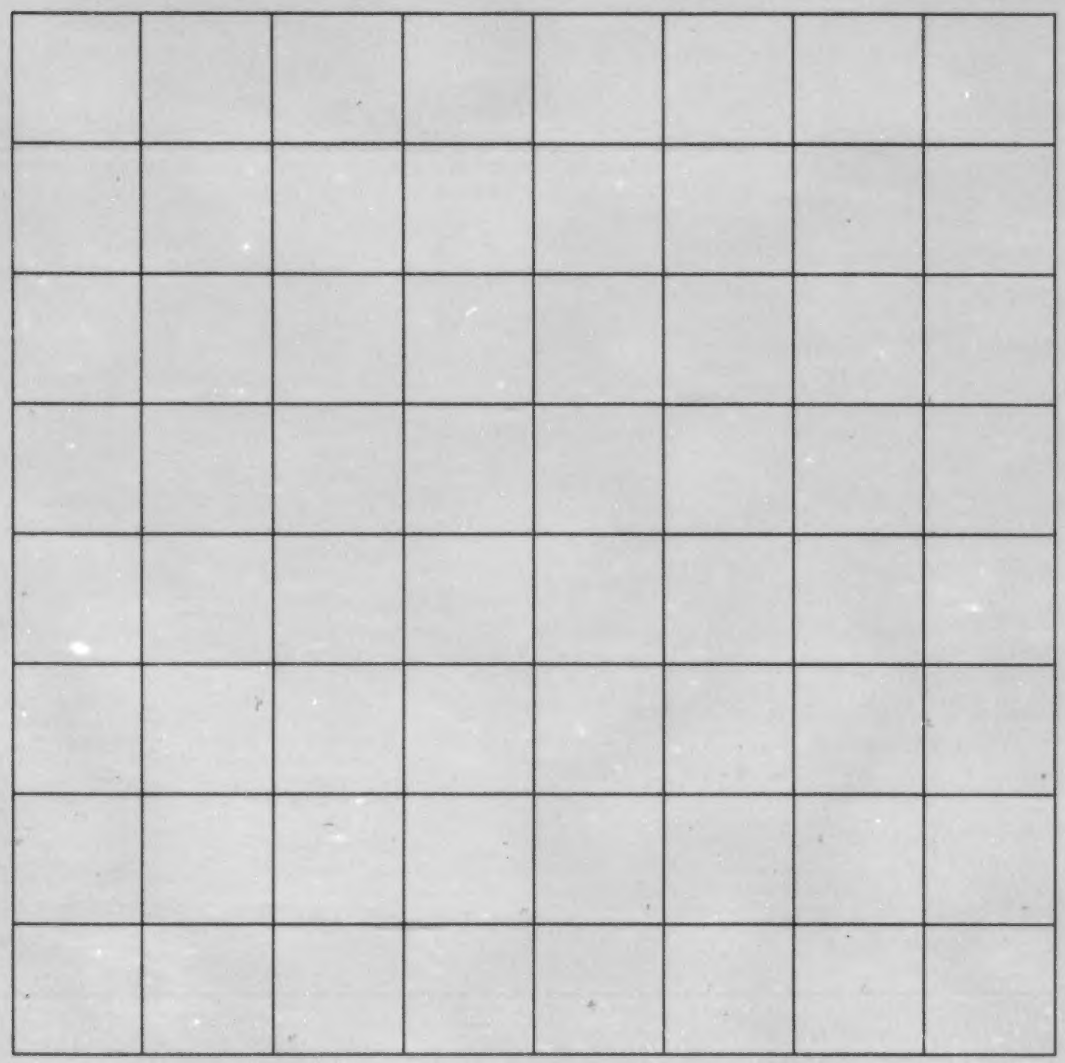
THE TROUBLE WITH EXPONENTIAL GROWTH

Procedure:

1. Give each student a checkerboard, some rice and directions to place one grain of rice in the lower left hand square, two grains in the next square, four in the next, eight in the next, 16 in the next and continue this pattern. Have students estimate the amount of rice they will need.

   When students realize they have run out of room and are faced with an impossible task, discuss these questions in class.
   a. Were you able to fill all the squares? If not, why not?
   b. How is the doubling of rice grains in the squares like our current consumption of energy?
   c. What will happen if we continue to consume energy at our present rate of consumption?
2. Discuss the game of "Rice Checkers". There are 64 squares on the board. If the number of grains of rice is doubled 63 times, that will be 2 to the 63rd power grains of rice on the 64th square. They would have to put more rice in the last square than there is rice in the whole world. No one was able to complete the game because he ran out of room. The current consumption of energy is increasing at a rapid rate too.
3. Show students how to calculate doubling time t_2, using the following expression: $t_2 = \frac{70}{\text{annual \% growth rate}}$
4. Calculate t_2 for each of the following examples:
   a. Inflation (and electricity consumption) at 7% per year.
   b. Population at 1.64% per year.
   c. Energy consumption at 3% per year.

RICE CHECKERBOARD



HOW'S YOUR ENERGY?

Source: Jerry Dunn
Ames High School
Ames, Iowa

Class: Science or English
Grades: 10-12
Time: 3 weeks

Concept: High school students become aware of current reference materials on energy and organize their information and thoughts regarding energy sources available to man.

Objective: To help students focus on the "What, Where, How and Why" of four selected energy sources as they explore reference materials and become aware of available energy sources.

Materials: Mini-packet on "How's Your Energy?"
Students will locate their own reference materials.

Procedure: Have students complete mini-packet.

Most of us use the word energy every day of our lives: "I have just lost all of my ENERGY. There is supposed to be an ENERGY crisis. The sun's ENERGY is warming the air. Our house is designed to save ENERGY." We all use the word but do we all know what we are really talking about? What is ENERGY, and where do we get the stuff?

Using reference books such as text books, encyclopedias, dictionaries, magazines, etc., answer the following questions to the best of your ability. The total packet is worth 100 points and will be evaluated as follows:

- 20 points — introduction
- 60 points — research — 15 points for each source
- 20 points — experiment, demonstration or drawing used to show just how one of the energy sources is available to mankind.

Possible Points	INTRODUCTION
1-4	We use several forms of energy each and every day of our lives. Write the definition of energy as stated in four different reference books. List the book, its copyright date, and the definition.
5-10	According to the thinkers of our day, all matter in the universe contains energy. Albert Einstein suggested that the relationship between matter and energy is a very close one. In fact, he suggested that one day we will understand how to convert matter into energy and energy into matter. This sounds good to most people, but just what is the matter? List at least six different forms of energy which might be available to you on a daily basis.
11-13	Write the definition of matter as stated in three different reference books. List the book and its copyright date with the definition.
14-18	Using your definition of matter, list at least five forms of matter that you came in contact with on your way to school this morning.
19-20	If all the matter listed contains energy, and the energy is not doing some work (causing something to move) then it must be stored energy. We call this __(19)__ energy. The matter which came in contact with that which was causing something to move or do work can be said to possess __(20)__ energy.

Possible Points:

RESEARCH

It becomes clear that our lives are dependent upon many forms of energy to help us do work. We drive cars, heat our homes, light our schools, grow our food, and in general use it for survival and convenience. In almost all cases this energy is not readily available in the form we can use. For example, we cannot pick up a sunbeam to run a fireplace. Energy to heat your room is locked up in wood, coal or petroleum. As intelligent human beings we have been able to take this potential energy and convert it into kinetic energy to serve our needs. We are the only animals on earth which have been able to do so.

One form of energy used by man is in the form of heat. Heat keeps us warm, moves our motors and machines, makes our metals, and provides us with artificial light (electricity).

In the remaining portion of this mini-course we will explore some potential sources of heat energy which are available to the world's human population.

60 Select four potential sources of heat energy used by people, i.e., coal, peat, natural gas, oil, etc. Research each heat source. Be sure to list reference, author and date the article was presented.

1. What source of potential energy are you investigating?
2. What is this energy used for?
3. What percentage of the United States energy is supplied by this source?
4. Where can this energy be found in greatest abundance?
5. Where does the United States obtain this source of energy?
6. Where are the waste products used, stored or gotten rid of?
7. How do we collect this energy?
8. How efficient is this energy as a source of heat?
9. How is this energy stored for later use?
10. How much energy is remaining for our future use?
11. Why is this a good source of energy?
12. Why is this a poor source of energy?
13. Why isn't this source of energy used more extensively?
14. Why are we concerned about the future use of this energy source?
15. In your opinion will we be using more, less, the same amount of this form of energy in 1990?

20 DEMONSTRATION

Pick one of the four sources of potential energy researched and demonstrate either with an experiment or with a drawing how that energy is made available for man's use. Demonstrations in which quantitative data are presented will be valued more than simple illustrations of principles.

TECHNICAL MANUAL

The Technical Manual consists of six major parts and a glossary. The first four parts recount the important experiences from the first year of the SEED program. They are designed as background and information for those engaged in energy conservation activities in schools.

The fifth part, the Schoolhouse Energy Audit Checklist, is a guide to conducting an energy audit. It is followed by Energy Report Forms, also guides to be used by the auditor in obtaining energy audit information required by the Department of Energy (DOE).

ENERGY MANAGEMENT

It is impossible to limit the discussion of remedies for energy inefficiencies to the bricks and mortar of the physical facility. The school building and the people who use it are inexorably linked, for much of the energy that can be saved is saved through the vigilance and cooperation of people.

The most important elements in implementing an effective energy management program are the commitment and team work of the people involved. School personnel are highly committed to provide quality education for students. They are equally committed to performing the other, supportive tasks necessary to insure that quality education is provided. In recent years a new activity has been added to the long list of tasks for superintendents — energy management. School administrators have come to embrace energy management as a valuable tool to assist them in holding down operating expenditures and channeling money into quality education services.

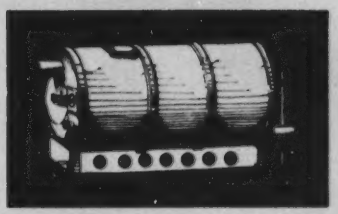
The commitment begins at the top, with the school board and superintendent. They begin by making the school community aware of problems relative to energy and motivating them to assist in solving those problems.

Everyone can have a role — from the school board to the principal, from the superintendent to Parent-Teacher groups, from the maintenance engineer to students and teachers in every classroom. Further, it is recommended that energy consevation goals be set and that the best approach to goal accomplishment is teamwork.

Energy conservation teams appointed by the superintendent are usually comprised of an energy coordinator, the business official, the maintenance engineer, a principal, a PTA member, a teacher and a student representative. In many school districts there are both district-wide teams and teams for each school.

The role of the team is to set out goals for energy conservation and to develop a plan to reach the established goals. Individual members of the team are then responsible for implementation of certain aspects of the plan. Typical roles might include the following:

School Board and Superintendent	• Establish policy
Energy Coordinator	• Coordinate the implementation of all energy conservation activities • Report to superintendent and school board
Business Official	• Keep accurate records of energy expenditures and projected savings • Monitor billings closely for an early detection of newly developing energy inefficiencies
Maintenance Engineer	• Keep all mechanical and electrical equipment in good operating condition • Make necessary modification to equipment and operating procedures to insure energy conservation
Principal	• Set the tone of energy conservation in the school • Post and enforce energy conservation guidelines and operating procedures for the school
Teacher	• Implement and monitor energy conservation in the classroom • Motivate students to learn about energy conservation
Students	• Assist in implementing and monitoring energy conservation activities



PHYSICAL CONSIDERATIONS OF ENERGY

While the audit team may include an engineer, it is not essential that everyone involved understand the theory of a building's energy usage. However, before beginning the analysis of a building's energy use, it is appropriate to understand where energy comes from and the means by which it can be gained or lost.

Heat Source

School buildings are heated primarily by boilers or furnaces. The boiler or furnace burns fuel, heating oil or natural gas, and extracts heat from the flame to make hot water or steam which is then delivered through pipes to the building. However, the combustion process itself will not yield all the heat that is available from the fuel. These limitations of the heating system are known as system inefficiencies. The boiler efficiency is the per cent of the available energy in the fuel it can extract and deliver to the rest of the heating system. Typical efficiencies range from 70% to 85%. A boiler of 75% efficiency extracts 75 BTU's of every 100 BTU's available in the fuel; the remaining 25 BTU's go up the chimney!

Heat Gains and Heat Losses

Heat gains and heat losses are affected by the following factors:

- Architectural characteristics;
- Environmental conditions, including the temperature, sun and wind;
- Building occupancy;
- Lighting and electrical power consumption; and
- Mechanical equipment.

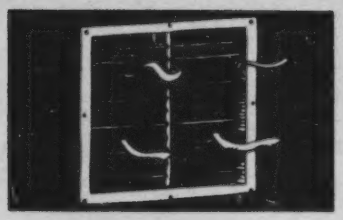
Heat loss features are transmission, ventilation and infiltration. Heat gain features are lighting and power, occupants and the sun. Following is a brief discussion of each.

Transmission

Heat flows through the building's exterior surface, or building envelope, i.e., through walls, roof, windows and floor. The flow of heat in this manner is known as transmission. Transmission is governed by three factors:

- The difference between indoor and outdoor temperatures;
- The amount of exterior surface area; and
- The thermal resistance of the surface. The thermal resistance of a material is called its "R" value. Heat transmission decreases directly as the R value increases.

Transmission is a prominent cause of heat loss, and since heat must be supplied at the same rate it is lost in order to maintain a fixed indoor temperature, transmission is the most costly mode of heat loss. An uninsulated roof usually loses the most heat, although if there is extensive glass area, the windows and doors may cause the greatest loss. Transmission loss through the floor is relatively small.



Infiltration and Ventilation

Transmission losses are attributable to heat flowing through surfaces, but does not include heat transported through a surface by air. Transported heat is known as infiltration and ventilation.

Air intentionally admitted and expelled from a building via windows, ventilators, and exhaust systems is ventilation. Air that unintentionally enters, leaves, or passes through the building, such as through window and door seals, building joints, and the passage of wind through ventilation systems, is known as infiltration. The entering air drives conditioned air out of the building. Therefore, the outside air that enters a building must be heated or cooled and dehumidified.

Heat loss due to ventilation is governed by three factors:

- Fresh air intake and exhaust rates;
- The time ventilators operate, e.g., the longer they operate the more heat is lost; and
- The temperature difference between the inside and outside of the building.

Heat losses due to infiltration are governed by four factors:

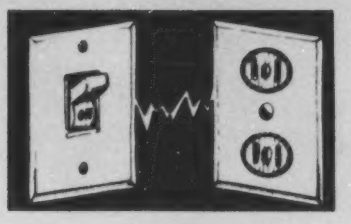
- Building orientation;
- Wind velocity and direction, e.g., those cracks directly facing the wind experience the most infiltration;
- Size of crack, i.e. width and length; and
- Temperature difference between the inside and outside of the building.

Some ventilation is necessary to maintain comfort in the building and to remove odors and contaminants. However, natural infiltration usually supplies the fresh air needed.

The major source of infiltration is where operable windows seal against window frames. Another serious infiltration problem is leaving windows open while the heating system is operating. Often a predominant source of infiltration is through ventilator fresh air intakes (FAI). Wind against exterior FAI grills, at average velocities, can cause fresh air to enter the building at four times the intended ventilation rate.

Occupants

Occupants emit body heat and humidity, a plus for heating and a burden for cooling. The extent to which body heat contributes to heating costs is related to the climate. The shorter the heating season, the less heat is contributed.



PHYSICAL CONSIDERATIONS OF ENERGY

Electrical Power/Lighting

Lighting contributes to heat in direct proportion to the wattage of the lamps used. This heat gain is beneficial in winter for it contributes heat which would otherwise have to be provided by mechanical systems. The opposite is true for the cooling season. Typically 90% of the electric power consumed within the building envelope heats the building contents; the other 10% escapes to the environment.

Solar Heat

The sun is beneficial in two ways: it helps to heat the building and provides free, high quality lighting. The specific effect of solar heat depends on the geographical area, the intensity and direction of the sun, the manner in which the building is situated, and the building's structural design.

Heat gain from the sun is prominent in the South, less so in the North. In northern climes, buildings with window areas situated east-west will receive the maximum benefit of solar heat gain. The opposite is true for the cooling season and window shades can be used to block direct sun, yet permit the use of sunlight.

Mechanical Equipment

Considerable energy is spent pumping water in hydronic heating systems, and in moving air via ventilators, exhaust fans, and boiler draft fans. For schools with hydronic heating systems, the energy used is equal to and often exceeds energy for lighting. The distribution of electric power consumption is roughly 40% each for lighting and pumps, and 20% for other items. Great opportunities for reduction in electric power consumption exist by reducing the flow rate of the water.

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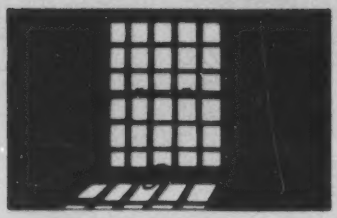


THE SEED AUDIT

An energy audit is a complete survey of a building to identify how energy is consumed and opportunities for energy conservation. The SEED audit stressed the importance the interrelationships of the building's structure and all of its working parts. For example, an action taken in one area of the building to conserve energy may adversely affect conditions in another making the conservation measure ineffective. Think of the building as a scale which, in order to be most energy efficient, must be in balance. One approach is to restore the "as designed" balance of the building, making modifications as necessary, and then to investigate additional energy conservation measures.

The Instrumented Audit

In order for the energy audit to be useful, the data collected must be accurate and complete. To help assure reliable data, it is recommended that instruments be used to verify written records. School operators may believe that energy conservation procedures are being implemented; however, upon verifying procedures with instruments they may find that a piece of control equipment is inoperative and thus ineffective.

Further, SEED recommends that data be collected under actual use conditions, i.e., when the building is fully occupied with all heating and lighting systems under normal use. In addition to this inspection, the SEED data collection process calls for a visit to the school late at night. Called the "midnight raid", the purpose of this visit is to record temperatures when outside temperatures are the coldest and to verify night set back and closure of fresh air intake devices.

Following is a list of the instruments used in the SEED audits, a description of what they measure, and a cost range.

Air Velocity Meter — A highly sensitive instrument used to determine the amount of air filtering in around doors and windows; also used to check the effectiveness of caulking and gasketing. Cost: $550-$650.

Grill Air Velocity Meter — Used to measure the rate of air flow through external and internal grills, e.g., unit ventilators; also used to check natural convection currents on rooftop exhaust stacks. Cost: $50-$100.

Immersion Thermometer — Used to measure the temperatures of the domestic hot water and the boiler stack. Cost: $20-$250.

Digital Thermometer — Used to determine room temperatures; also useful in calibrating thermostats. Cost: $150-$350.

Illumination Level Meter — A light meter used to measure light levels in rooms and corridors. Cost: $125-$200.

Orsat Apparatus — An instrument used to measure the efficiency of the boiler in its use of fuel. Cost: $150-$250.

THE SEED AUDIT

The SEED Audit Process

In addition to identifying problems and opportunities, the energy audit and subsequent data analysis defines the framework for an effective energy management program. The data analysis provides realistic quantifiable estimates of where energy and money may be saved. It points out the areas of greatest loss and therefore the areas of greatest energy saving opportunities. In this manner, this process assists in setting priorities for energy conservation activities.

The SEED energy audit process consists of three major steps: the pre-audit, the full audit survey and a presentation of the results. The pre-audit is the data collection and preliminary analysis phase of the audit process. At this time, monthly fuel and power consumption records and billing schedules for at least the past year or two are assembled. Weather data for recent years are collected from the local weather station or the National Oceanic and Atmospheric Administration. Architectural drawings, including modifications and additions, are inspected to compute square footage, percentage of wall area, amount of window area, and the insulating properties of construction materials. Mechanical and electrical specifications are examined to determine power demands. A careful examination of the data collected will point out potential areas of energy inefficiencies. At this time, a boiler efficiency test is made to determine how much of the fuel consumed is actually used to heat the building.

Once the anomalies between the as-designed and actual energy consumption rates are defined, the full on-site audit inspection is conducted looking for opportunities to correct those anomalies and save energy.

During the full audit, the audit team surveys the building thoroughly, using the instruments listed earlier. Careful observations of all of the energy consuming features of the building are made and documented. Temperatures, both day and night, and light levels are measured in every room including the corridors. The heating and cooling system is inspected including unit ventilators, fresh air inlets and rooftop exhaust fans. An air velocity meter is used to inspect doors and windows for air infiltration. An immersion thermometer is used to determine the temperature of the potable hot water. In addition, the audit team interviews the principal and maintenance personnel to determine building use and number of occupants. These interviews are extremely valuable not only for the information gathered but also for conveying the importance of energy conservation to those who operate the building.

Once the audit survey and data analysis are complete a written report is prepared. The report clearly and precisely enumerates the problems and lists alternative recommendations. To assist the school administrator in justifying expenditures, cost estimates are provided for each proposed solution. The length of time required to recover the initial cost (payback period) is included as an additional tool to justify expenditures. Payback periods should be used with caution as they are only a good yardstick for determining relative costs. The recommendations suggest priorities based upon the amount of energy saved, cost estimates, payback period, and the effect of each recommendation on other problems and/or proposed solutions.

SEED learned many things — most are already known and widely used by energy managers across the country. Like other programs, SEED problem analysis and recommendations included:

- Keeping doors and windows closed;
- Weatherstripping and rehanging improperly fitting doors;
- Sealing and caulking leaky window areas;
- Calibrating thermostats and reducing temperature settings; and
- Turning off lights and other equipment when not in use.

Some ideas and energy conservation techniques were learned from people involved in SEED. In Livonia, Michigan, at Roosevelt Elementary School SEED learned that placing pegboard over fresh air inlets is an extremely effective way to limit the amount of outside air coming into the building.

A few energy saving procedures and techniques are key to the SEED approach to energy conservation. It is these that are discussed in the following sections.

Window Treatment

One of the greatest causes of heat loss is transmission through windows. Glass is a very poor insulator and single glazed windows, even when shaded, lose heat at a very high rate. The typical R value for windows range from only 0.8 to 1.1. Transmission is exacerbated by heating ventilators, usually located beneath the window, which emit heat closest to the place where it can be lost. Typically, losses through single glazed windows cost about 86¢ per square foot per year. Costs are relative and subject to change but are included here to provide the reader some guidelines for projecting expenditures.

There are several ways to reduce transmission through windows including removing windows and permanently bricking a portion of the space, installing storm windows and insulating window panes.

Because one of the criteria of the SEED program was low cost remedies to energy loss, the option of window insulation was pursued. Even this was difficult for much of the available window insulating material was very expensive and would exceed the budget of most school districts.

For SEED, the criteria for window insulating material is that it be aesthetic, lightweight, non-toxic, translucent and non-flammable. It should be easy to install such that school personnel can put it in, further minimizing the cost. An additional important requirement is that the insulation be sealed completely and tightly to the existing window frame. No air movement should be permitted between the glass and the insulation. This "dead space" adds to the insulating properties of the treatment.

One must exercise caution when insulating tinted glass for it may crack due to stress from expansion by overheating. The windows most vulnerable to cracking are those with east-west exposure.

Two window insulations were identified which meet the criteria listed above: duct board, and Tuffak or Cyrolon.

Duct board is a rigid fiberglass material, 1 inch thick, with aluminum foil backing. It is opaque and gives the window an R4 rating. It is easy to install, applying it to the window frame with duct tape. In addition, it is non-flammable and inexpensive, costing less than 50¢ per square foot, installed. However, its disadvantages are its opacity and questionable appearance.

The Tuffak or Cyrolon is a light cellular plastic (polycarbonate) material, approximately ⅝ inch thick, available in translucent white. They may be applied to the window frame with 1.5 inch adhesive tape or with a clear silicone adhesive. Following installation, the window will have approximately a R2 + value, reducing heat transmission by 70%, with a light transmittance of 70%. The major disadvantage of this material is cost — approximately $4.00 per square foot, installed. In addition, State fire codes should be checked very carefully prior to installation of this material. Some are so restrictive as to prohibit the use of this material.

SPECIAL FROM SEED

With these two options, SEED had identified one product which was effective and inexpensive, but unaesthetic, and another which was effective and visually pleasing, but expensive. A third alternative was discovered, an experimental window insulation developed by a leading manufacturer of glass insulation. It is a semi-rigid, man-made fiberous material, with an R factor of 3+, which will reduce heat loss as much as 80%. The material is translucent and will allow the direct utilization of solar energy for heating. Moreover, the cost is only $1.00 per square foot.

Testing of this material is underway in three of the SEED audited schools: Lancaster, New York; Havertown, Pennsylvania; and Pawtucket, Rhode Island. If tests prove satisfactory and this product becomes commercially available, Tenneco will notify the various national education groups so that they can alert their membership.

	DUCT BOARD	TUFFAK or CYROLON	DEVELOPMENTAL SYSTEM
Cost	50¢/sq. ft.	$4.00/sq. ft.	$1.00/sq. ft.
R Value	4	2+	3+
Transparency	0	70%	40%
Light Weight	Yes	Yes	Yes
Toxicity	Very Low	Acceptably Low	Very Low
Flammability	None	Acceptably Low	None
Durability	Fair	Very Good	Very Good
Appearance	Poor	Good	Good
Payback Period	8 months	5 years	12 months

Excessive Fresh Air

In most schools an excessive amount of fresh air is introduced and moved through the classrooms and corridors. The problem with excessive fresh air coming into a building is that it must be heated and/or cooled. In addition, the constant movement of air across the skin helps to make us feel cold even when the temperature is at an acceptable level. In the SEED experience, the rates of fresh air intake and exhausts were too high. Previous building code requirements in some areas were as high as 10 cfm per person for classrooms and offices. However, the new American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) standard of 4 cfm, enough to control odors and contaminants, has been accepted as code in many states.

Fresh air is admitted into a building two ways: unit ventilators and exhaust fans. The mechanism for introduction of fresh air is through a grill on the outside of the building wall. The outside air is mixed with inside recirculated air, a process which is controlled by a damper inside the ventilator itself. When the wind blows, even more fresh air is introduced. Measurements in SEED audits show that for normal, 10 miles per hour winter wind, the amount of fresh air entering the building quadruples on the windward side of the building, and warm building air actually flows out the grill on the leeward side, overcoming the positive pressure of the ventilator fan. At 10 cfm for a typical classroom, the unit ventilator admits fresh air costing approximately $80 per year to heat.

Other problems with ventilators include:

- Improper damper settings; and
- Damage to exterior grill, causing damper to remain open.

Exhaust fans, on rooftops or other places, further complicate the problem of excessive outside air because too much treated or conditioned air may be expelled from the building causing an equivalent amount of outside air to be drawn into the building.

There are numerous ways to limit excessive amounts of fresh air from entering or leaving a building.

- Adjust dampers on fresh air intake to allow only the minimum required by State code;
- Reduce the speed of the fan in the unit ventilator;
- Deactivate and seal unnecessary exhaust fans;
- Insure that operable exhaust fans have dampers; and
- Place operable exhaust fans on timers.

An excellent solution to limiting the amount of fresh air admitted to the classroom through the unit ventilator is to place pegboard over the grill of the fresh air inlet. The pegboard will restrict fresh air intake to a limited amount regardless of the damper setting. In addition, it protects the grill from damage. Pegboard is easy to cut, install and replace. Moreover, it is inexpensive, costing about $20 per unit ventilator.

Lighting

The problems with lighting fall into several categories: the use of inefficient types of lights, the use of too much artificial light and poor quality lighting.

It is widely known that incandescent lights use more energy and last a shorter time than standard fluorescent lamps. In recent years a more efficient fluorescent lamp has been developed. Moreover, for exterior lights and areas where the quality of light is not critical, e.g., gyms and cafeterias, multivapor and high pressure sodium lamps have been developed. These are even more efficient users of energy.

The following table is a comparison of types of available lighting:

	COST	RELATIVE EFFICIENCY	HOURS	COLOR QUALITY
Incandescent	Low	1	1,000	Good
Fluorescent	Moderate	4	20,000	Good
Mercury Vapor	High	3	20,000	Fair
Multivapor	Very High	4	15,000	Fair-Good
High Pressure Sodium	Very High	5	20,000	Poor

SEED recommends the use of high efficiency fluorescent lamps in classrooms, offices, libraries and corridors. It recommends the use of multivapor or sodium lamps in gymnasia, multi-purpose rooms and for exterior security lighting.

Most schools are over-illuminated with artificial light. It is recommended that all unnecessary lights be turned off and ballasts be disconnected. Further, artificial light is used near windows where sufficient daylight is available for reading and writing. Use of a light meter will quickly determine which lights are unnecessary. Acceptable lighting levels are 70 footcandles for task or close work, 50 footcandles for general areas, and 20 footcandles for corridors.

Usually classroom lights are arranged in three rows of fluorescent lamps, parallel to the window. Each row can have a separate switch. To take advantage of the daylight, leave window shades open and turn off the row of lights closest to the window. If rows are not parallel and/or if separate switching is not available, delamp the fixtures closest to the window. This simple procedure can reduce electric power consumption by 10 to 25 per cent.

SEED not only addressed the technical aspects of lighting but also addressed its affect on visual quality for those who use it. Further, ways to optimize the use of lighting were explored. Although lighting requirements in the past have been in quantity of illumination or footcandles, it has been recognized that this does not necessarily satisfy the eye's requirements to accomplish a visual task. There are two factors that assist the eye in comfortable vision: contrast and illumination level.

There are several factors that influence contrast and illumination level:

- The darkness of ink or pencil lines;
- Whether the ink is glossy or non-glossy;
- Whiteness of paper;
- Orientation of light source with respect to readers;
- Glare; and
- Type of light source and fixture combinations.

The following are typical SEED recommendations designed to optimize the light provided:

- Students should use No. 2 pencils; if ink is used, black ink is preferable.
- Paper for writing and reading should be very white and non-glossy.
- Students should be oriented between and parallel to the lighting.
- Light through windows is advantageous to vision and should be employed.
- Walls, ceiling and floor should be a light color so as to increase the reflectivity of light.
- Light fixtures should be cleaned regularly; paint them white if necessary.

The Heating System

Proper setting and monitoring of thermostats, both in classrooms and on the boiler, provide one of the greatest energy saving opportunities. The experience of SEED indicates that a school can save as much as 30% of its energy consumption by careful tuning and operation of its temperature systems. Common to most schools and a serious problem is that night, weekend and after hours temperatures were much higher than intended. An acceptable level is 55°F, provided the building envelope is tight. And, the building can be brought back to comfortable conditions, around 65°F in a moderate amount of time.

The importance of the after hours setting cannot be overstated. The school is usually under day thermostat control only 35 hours a week, as compared to night thermostat control for 133 hours, a ratio of more than a 3.5 to 1. This means that it would cost no more to heat the school an additional 3.5°F during the day, as long as the night temperature is lowered 1°F. Thus, the temperature control program is most effective if it concentrates on the after hours temperatures.

To help this serious inefficiency and in addition to calibrating and lowering the setting of thermostats, it is recommended that boilers be turned off on nights and weekends. Care must be taken to prevent the freezing of pipes. There are at least two ways to prevent the freezing:

- Install a small hydronic pump parallel to the main pump for operation at nights and on weekends. The small pump will maintain enough flow to prevent freezing and allow the main pump which consumes more energy to be turned off.
- Install a thermostat in the coldest room which will trigger the boilers and pumps should the temperature drop to the danger level.

An additional savings opportunity presented by the boiler is in the production and delivery of potable hot water. Although no heating may be required, the main boiler is often fired only to heat water for the kitchen and shower. Not only is the water heated but all of the pipes through which it passes must be heated.

To avoid firing the boilers only to heat water, it is recommended that schools install independent, gas fired water heaters. A new water heater will cost from $500 to $1,250 but the cost can be recovered in a short amount of time.

Fans and Hydronic Pumps

Most schools are heated by a hydronic system, i.e., a circulating hot water system. Much energy is spent to operate this system of fans and pumps. There are fans in the ventilators and exhausts, and there are pumps throughout the system to keep the water moving. In this instance, energy savings opportunities result from previous activities of tightening the building envelope and reducing temperatures. Therefore, the pumping system is not required to work as often and the rate at which the hydronic pumps and fans must operate can be reduced.

Lowering flow rates by 24% reduces the energy required to move the air or water by more than 50%. The hydronic flow rate is reduced most economically by shaving the diameter of the pump's impeller on a lathe.

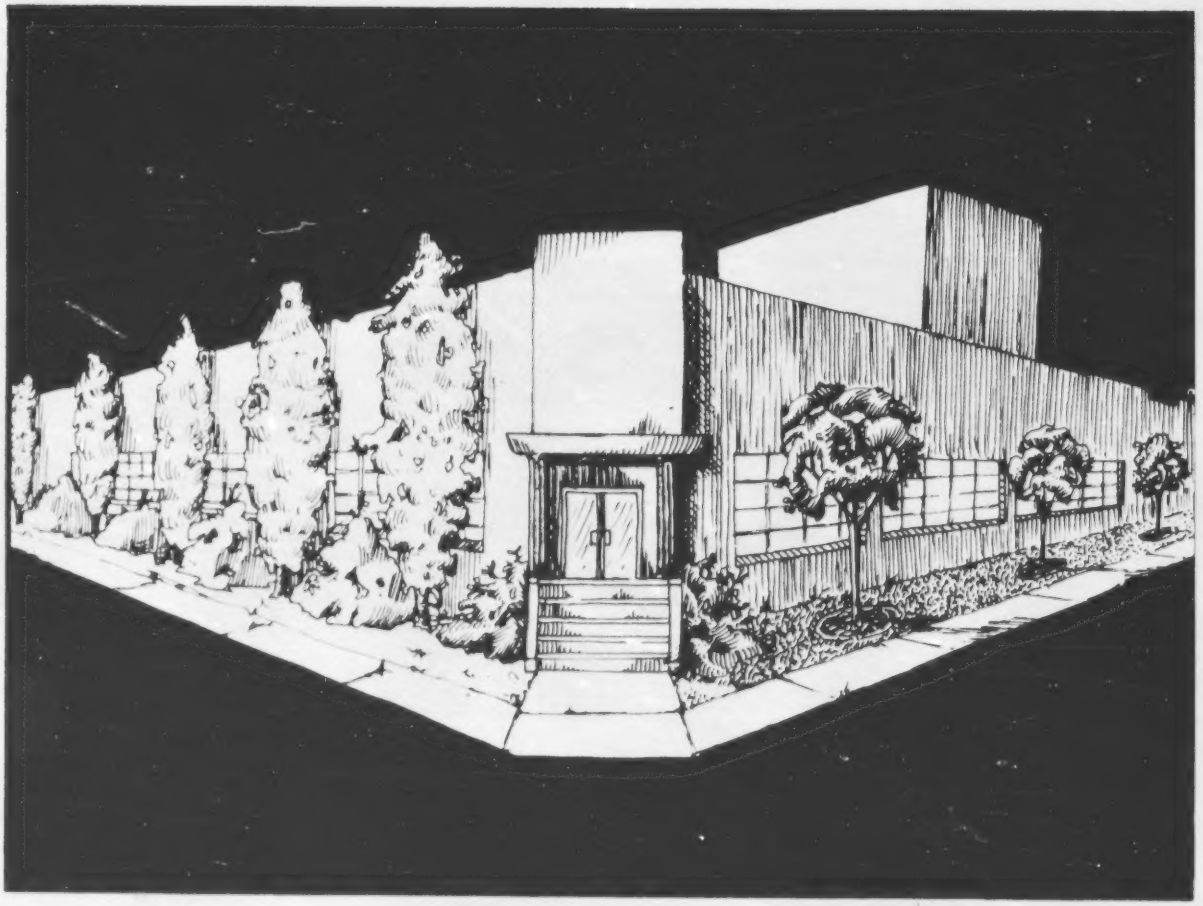
The air flow rate can be reduced by lowering the rotation speed of the fan. This can be done by changing pulleys or pulley chains or replacing the motor with one having a lower rotation speed.

Summary

In summary, there is a proper sequence in which SEED believes the remedies should be implemented:

- Tighten the building envelope, including insulating windows, weatherstripping, caulking and reducing ventilation and exhausts;
- Lower the building temperature, especially the night and weekend settings; and
- Modify the mechanical systems.

The lighting modifications can be implemented at any point in the energy management program.



SCHOOLHOUSE ENERGY AUDIT CHECKLIST

This section comprises the core of an energy audit. It is designed as a guide to provide an energy management team with a convenient, organized listing of areas of energy waste and inefficiency most commonly found in school buildings.

While conducting the tour through the building, use each INDICATOR in the order it appears to help quickly identify conditions of energy misuse. If the "TRUE" box is checked (√), the INDICATOR as stated implies good energy management; no remedial action is necessary. If, however, the INDICATOR is false, check (√) the "FALSE" box. Remedial action is then required. Use the "NOTES" space to record special problems "uncovered" in your tour.

When this section has been completed, the team should review those INDICATORS which have been checked "FALSE", their implications and any special notes.

The first remedial action taken should be the Lower Cost Corrections, operational and maintenance opportunities (O&M's), and are suggested in the center boxes. Where applicable, these suggestions should be assigned to specific personnel and implemented immediately. By themselves they can reduce energy consumption by 30-50% in buildings where no improvements in energy efficiency have yet been made.

Finally, consider each applicable suggestion in the boxes labeled "Higher Cost Corrections". These are redesign, retrofit or energy conservation measures (ECM's), and will usually require capital expenditures to implement. Professional architects and/or engineers should be consulted prior to their implementation. Payback and life-cycle cost analysis should also be conducted before any of these decisions are made in order to determine which will save the most energy dollars.

Please note that in order to qualify for Federal funds, the auditor must check those O&M's necessary to accomplish energy conservation in the school. Then the school must implement them. If the auditor is unsure about a particular O&M, he should so indicate with a question (?) mark and the school should investigate that action further. In addition, in order to provide some continuity and consistency between Tenneco's Energy Audit Checklist and the Department of Energy's recommended audit procedure, some of the concepts and formatting used here are similar.

I. HUMAN SYSTEMS

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. The change of seasons has been reflected in thermostat settings. TRUE ☐ FALSE ☐ NOTES: _____	☐ Adjust thermostat settings so that room temperatures of occupied areas are 68°F in heating season and 78°F during cooling season.	☐ Replace existing thermostat with a thermostat which has a separate setting for cooling and a separate setting for heating, or use one thermostat to control heating and one thermostat to control cooling.

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Location of all thermostats provides for moderate temperature fluctuations. TRUE ☐ FALSE ☐ NOTES: _____	☐ Move thermostats from areas next to windows, doors, heating or cooling units to areas which reflect temperatures of conditioned spaces more accurately. ☐ If thermostat cannot be moved, protect it from the source creating fluctuation.	☐ Relocate thermostat in HVAC return system, where possible.

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Areas which are unoccupied or minimally used have modified heating/cooling temperature settings. TRUE ☐ FALSE ☐ NOTES: _____	☐ Turn off heating system or close heat register if nothing in space can freeze. ☐ If area has its own thermostat, reduce heat setting to 55°F. ☐ Turn off cooling system or close registers. ☐ Use infra-red spot heaters in large spaces with low occupancy.	☐ Reduce heating/cooling demands of unoccupied areas with appropriate control systems.

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Activities, including custodial services, not normally considered part of the school day, are scheduled to reflect wise energy management. TRUE ☐ FALSE ☐ NOTES: _____	☐ Reschedule activities to accommodate partial reduction of energy demand. ☐ Consolidate activities to reduce building usage. ☐ Reschedule cleaning and maintenance activities during daylight working hours where possible. ☐ Where rescheduling is not possible, use lights and equipment only in those areas where individuals are working.	☐ Consider installing an automated energy control system that will predetermine the environment of occupied spaces.

I. HUMAN SYSTEMS

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Temperatures have been adjusted to reflect temporary usage of lobbies, corridors, vestibules and other public places. TRUE ☐ FALSE ☐ NOTES: _____	☐ Reduce heat supply to these areas. ☐ Disconnect or turn off electric heaters in these areas unless it creates a freeze-up problem. ☐ Discontinue air conditioning of these areas.	None practical

PATTERNS OF USE INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
# 6. Building temperatures have been reduced to reflect unoccupied periods. TRUE ☐ FALSE ☐ NOTES: _____	☐ Reduce thermostat settings to 50°F when building is unoccuped during heating season. Begin reduction of heating during last hour of occupancy. ☐ Turn off all air conditioning units when building is unoccupied. ☐ Experiment with heating "turn-on" times to determine length of pre-heat period required for satisfactory comfort levels of occupants. ☐ Install appropriate automatic controls; e.g., time clocks.	None practical

OCCUPANT IMPACT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Thermostats are locked to eliminate unauthorized adjustment. TRUE ☐ FALSE ☐ NOTES: _____	☐ Install locking screws. ☐ Post signs displaying proper thermostat setting. ☐ Replace defective thermostat with non-adjustable pre-set thermostats. ☐ Install tamper-proof covers.	☐ Relocate thermostat in HVAC return system, where possible.

OCCUPANT IMPACT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Staff utilizes blinds, curtains and other window-covering devices to reduce energy usage. TRUE ☐ FALSE ☐ NOTES: _____	☐ Instruct staff on techniques of reducing energy consumption with blinds, curtains and other window-covering devices. ☐ Inform staff to use natural lighting and solar heat gain when appropriate. ☐ Repair damaged shading devices. ☐ Install devices where needed.	☐ Install reflective or heat absorbing films in areas with excessive heat gain in summer.

I. HUMAN SYSTEMS

OCCUPANT IMPACT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. The school provides a suitable inservice training program for building staff in the importance and techniques of wise energy use. TRUE ☐ FALSE ☐ NOTES: _____	☐ Appoint interested individuals to develop and implement an energy management program for staff. ☐ Extend the training program to include students through appropriate instruction. ☐ Remind staff and students of good energy conservation techniques through the utilization of Energy Conservation Plaques.	None practical.

OCCUPANT IMPACT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Occupants turn off lights in unoccupied areas. TRUE ☐ FALSE ☐ NOTES: _____	☐ Instruct staff on importance of conservation of electrical energy. ☐ Utilize only necessary lighting in large areas such as libraries, gymnasiums, auditoriums and cafeterias. ☐ Color-code switches to indicate minimum levels of light needed for normal activities.	☐ Install automatic timing switches in areas used for short periods, such as storerooms and janitors' closets. ☐ Rewire switches so that one switch does not control all fixtures in multiple task areas.

OCCUPANT IMPACT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Doors and windows remain closed while building is being heated or cooled.	☐ Instruct staff to keep doors and windows closed while building air is being conditioned.	None practical.
TRUE ☐ FALSE ☐	☐ Adjust door mechanism for faster closing.	
NOTES: _____	☐ Remove device which allows doors to be locked open.	
	☐ Permanently seal unnecessary operable windows.	

II. STRUCTURAL SYSTEMS

DOORS INDICATORS	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. All exterior doors are aligned properly, fit tightly and operate efficiently.	☐ Realign doors that do not close properly.	☐ Consider installing vestibule doors at heavily used entrances.
TRUE ☐ FALSE ☐	☐ Replace or readjust automatic door closing.	☐ Install mechanisms which automatically close doors to unconditioned spaces.
NOTES: _____	☐ Repair or replace threshholds and/or gaskets.	☐ Consider installing removable center posts with proper gaskets for double doors with large gaps.
	☐ Repair or replace weatherstripping.	☐ Consider installing wind screens to protect exterior doors from direct blasts of prevailing winds.
		☐ Insulate large exterior doors.

WINDOWS INDICATORS	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. All windows on exterior walls are aligned properly, fit tightly and operate effectively. TRUE ☐ FALSE ☐ NOTES: _____	☐ Realign windows that do not close properly. ☐ Permanently seal those which cannot be properly aligned. ☐ Caulk and weatherstrip windows. ☐ Replace any broken or cracked windows.	☐ Consider replacing faulty or non-essential windows with walls or insulated panels. ☐ Consider replacing deteriorated or badly fitting frames with new energy efficient models. ☐ Install wall or insulated panel if window is not essential.

WINDOWS INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Exterior walls have little excessive glassed areas. TRUE ☐ FALSE ☐ NOTES: _____	☐ Insulate the upper portion of each window.	☐ Consider replacing windows with walls or insulated panels. ☐ Install double pane windows if cost-effective. ☐ Investigate other products such as reflective or heat absorbing film. (Be sure to anticipate maintenance problems.) ☐ Use thermopane windows (utilizing the same casings) when replacing windows.

II. STRUCTURAL SYSTEMS

WALLS INDICATOR	LOWER COST CORRECTIONS (O&M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Penetrations in exterior walls and the joints where different wall materials join have been properly caulked. TRUE ☐ FALSE ☐ NOTES: _____	☐ Ensure that all areas of potential air infiltration are sealed, using quality caulking materials. ☐ Cover all window cooling units when not in use to prevent air leakage through the units.	None practical

WALLS INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Wall insulation is adequate for local weather conditions. TRUE ☐ FALSE ☐ NOTES: _____	None practical	☐ Consider adding insulation to increase the R-factor, when remodeling or when replacing segments of the exterior wall.

ROOFS INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
1. Roof is adequately insulated for local weather conditions.	☐ Ensure that the vapor barrier faces the conditioned space.	☐ Bring the current insulation level up to standard recommended for your climate. ☐ Replace any water-damaged insulation.

TRUE ☐ FALSE ☐

NOTES: _____

ROOFS INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Skylights have been modified to reflect wise energy management.	☐ Caulk and seal around entire skylight. ☐ Be certain glass or plastic is in good condition to prevent air infiltration and heat loss. ☐ Install an additional glass or plastic barrier to reduce heat loss. ☐ Insulate skylight with a translucent insulating material.	☐ Replace skylight with insulating materials.

TRUE ☐ FALSE ☐

NOTES: _____

III. LIGHTING SYSTEMS

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Incandescent lamps are used rarely except for decorative purposes. TRUE ☐ FALSE ☐ NOTES: _____	☐ Replace burned-out incandescent lamps with lower wattage types, where possible. ☐ Consider replacing incandescent lamps with lower-wattage, self-ballasting mercury vapor bulbs in large areas such as gymnasiums, cafeterias and auditoriums. (Note: Be sure at least one incandescent bulb is left in to provide a safety light should the mercury vapor lamps be accidentally turned off.) ☐ Discontinue use of extended service lamps in locations where they can be replaced easily.	☐ Substitute energy conserving lamps for non-decorative incandescent lamps. The former provides more light for less wattage at lower cost.

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Wherever fluorescent lamps have been removed, the ballasts have been properly disconnected. TRUE ☐ FALSE ☐ NOTES: _____	☐ Remove or disconnect ballasts. (Note: Although they appear inactive, ballasts consume significant amounts of electricity even though the lamps have been removed.)	☐ Investigate replacing unnecessary tubes with models which draw a small current, yet provide a uniform lighting effect.

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. The entire school has been relamped with energy efficient fluorescent tubes, and ballasts have been replaced as needed with energy conserving types.	☐ Replace defective fluorescent tubes with more efficient and lower wattage types. ☐ Replace burned-out ballasts with more efficient, lower wattage models.	☐ Install more efficient, lower wattage fluorescent tubes in all fixtures.

TRUE ☐ FALSE ☐

NOTES: _____

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Proper delamping, the removal of unnecessary fluorescent tubes and incandescent bulbs, has been completed.	☐ Do not replace defective fluorescent tubes in areas where delamping is feasible. In four-lamp fixtures allow two lamps to remain, disconnecting appropriate ballasts. ☐ Do not replace burned-out incandescent bulbs in areas where delamping is feasible.	☐ Consider lowering fixtures in order to increase illumination levels on task areas. Higher illumination levels will allow a delamping program. ☐ Consider removing entire fixtures in areas where illumination is excessive. ☐ Install three-tube fixtures which allow three levels of illumination for varying tasks, when remodeling.

TRUE ☐ FALSE ☐

NOTES: _____

III. LIGHTING SYSTEMS

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Routine cleaning of lamps, tubes and fixtures is part of the energy management program.	☐ Clean lamps, tubes and fixtures regularly.	None practical
	☐ Replace yellowed, cracked or defective light diffusers as needed.	

TRUE ☐ FALSE ☐

NOTES: _____

INTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#6. Natural lighting is optimized.	☐ Clean walls regularly.	None practical
	☐ Repaint with light reflective, non-glossy colors to enhance illumination.	
	☐ Clean windows on a routine basis.	
	☐ Use drapes, blinds and curtains to increase natural light gain.	

TRUE ☐ FALSE ☐

NOTES: _____

EXTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Defective exterior lamps and/or fixtures have been replaced with more energy efficient types. TRUE ☐ FALSE ☐ NOTES: _____	☐ Replace 150-watt security flood lights with 75-watt lamps. ☐ Consider blacking-out building and grounds during unoccupied night time periods. (Note: Some school districts have had success with this program.) ☐ Consider using remotely monitored intrusion alarms.	☐ Replace defective exterior lamps with mercury vapor, metal halide or high-pressure sodium lamps.

EXTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Exterior lighting is automatically controlled. TRUE ☐ FALSE ☐ NOTES: _____	☐ Reduce hours of operation of exterior lights. ☐ Ensure proper functioning of photo-cell controls.	☐ Install automatic lighting controls if needed. ☐ Modify the control system to include photocell "turn-on" and time clock "turn-off".

III. LIGHTING SYSTEMS

EXTERIOR INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Playing field lighting system has been upgraded to save energy dollars. TRUE ☐ FALSE ☐ NOTES: _____	☐ Clean lighting fixtures regularly. ☐ Maintain and refinish lighting reflectors, as required, to obtain maximum illumination. ☐ Use only lights required during night practice periods.	☐ Replace incandescent lamps with more efficient and effective models such as high-pressure sodium or metal halides. ☐ Install separate meter for playing field lights to reduce total electrical demand, if applicable. (Note: This procedure will not save energy but can save dollars.)

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Multiple boilers or heaters have been modified to prevent simultaneous firing.	☐ Adjust boiler or furnace controls so that unit #2 will not fire until unit #1 can no longer satisfy demand.	☐ Install automatic staging controls, if needed.

TRUE ☐ FALSE ☐

NOTES: _____

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Stack temperature is in normal range as verified by routine flue gas analysis.	☐ Perform regular flue gas testing to ensure proper air to fuel ratio and make necessary corrections. (Example: Clean air intake filters; check that spuds and nozzles are properly sized and not clogged; ensure that fuel pressures are not excessive, and there is an adequate supply of combustion air.)	☐ Purchase kit for flue gas analysis, or digital flue gas analyzer.
	☐ Reduce the boiler's firing rate.	

TRUE ☐ FALSE ☐

NOTES: _____

IV. MECHANICAL SYSTEMS

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Thermostat settings accurately reflect room temperatures. TRUE ☐ FALSE ☐ NOTES: _____	☐ Recalibrate thermostats and controllers. ☐ Bleed and clean pneumatic lines, if applicable. ☐ Clean contacts of electrical control system, if applicable. ☐ Ensure that control valves and dampers are modulated properly and that heat distribution to space is unobstructed.	☐ Investigate new types of thermostatic control devices for application in specific situations. Install suitable type.

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Automatic controls schedule heating water temperature in accordance with outdoor temperature. TRUE ☐ FALSE ☐ NOTES: _____	☐ Check temperature of hot water in heating system. If it appears excessive during periods of mild weather: a. Ensure that reset controls are functioning properly. b. Experiment with hot water temperature reduction when an acceptable comfort level is attained. ☐ Turn off boiler, pumps or heat source during summer. ☐ If the building has been properly caulked, sealed, weatherstripped and insulated, turn the boilers off at night. Exercise caution if the outside temperature is expected to go below freezing. In addition, make certain that the boiler will tolerate being turned off.	☐ Install temperature controls which automatically program water temperature according to outdoor temperature and will turn off heating unit when outside temperature reaches 60°F.

IV. MECHANICAL SYSTEMS

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Heating pilot lights are scheduled to be turned off during summer. TRUE ☐ FALSE ☐ NOTES _____	☐ Turn pilot(s) off on prescheduled date. ☐ Post a reminder in boiler/furnace room of pilot reactivation date.	☐ Replace pilot lights with new electronic ignition models whenever feasible.

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#6. Steam radiators and other steam equipment are maintained regularly for proper functioning. TRUE ☐ FALSE ☐ NOTES: _____	☐ Replace defective air vent valves. ☐ Clean thermostatic control valves on radiators. Replace if necessary. ☐ Clean or replace bellows element in defective thermostatic traps. ☐ Check the temperature on the down stream side of steam traps. Unless the pipe is moderately hot (as hot as a water pipe), it is malfunctioning. Take appropriate action.	☐ Reclaim steam trap heat losses by diverting the steam-vacuum system exhaust through a potable hot water pre-heat tank.

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#7. Insulation on hot water pipes has been inspected, is adequate and is in good condition.	☐ Replace damaged or missing insulation.	☐ Install additional pipe insulation in accordance with good energy conservation practices.

TRUE ☐ FALSE ☐

NOTES: _____

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#8. Oil burner is operating efficiently without excessive smoke or sooting.	☐ Check for proper oil pressure. Adjust as required. ☐ Confirm that oil is at proper temperature and free-flowing. ☐ Inspect burner nozzles for cleanliness and correct spray angles. ☐ Verify proper air to fuel ratio by routine flue gas analysis. ☐ Reduce firing rate.	☐ Purchase vent for flue gas analysis or a digital flue gas analyzer.

TRUE ☐ FALSE ☐

NOTES: _____

IV. MECHANICAL SYSTEMS

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#9. Routine maintenance is employed to insure efficient operating of heating units. TRUE ☐ FALSE ☐ NOTES: _____	Boilers: ☐ Remove soot from tubes during routine maintenance. ☐ Remove scale deposits, sediments and precipitates on water-side surfaces. (Note: Rear portion of boiler is most susceptible to scale formation.) ☐ Repair all damaged or worn boiler insulation, refractory, brickwork and boiler casings. Furnaces: ☐ Repair or replace solenoid valve if fire does not cut off immediately when unit shuts down. Both: ☐ Reset hot water temperature. Limit switch to a higher setting if burner short cycles. ☐ Reduce firing rate.	☐ Replace dangerous or ineffective units with more efficient models.

HEATING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#10. Hot water/steam radiation units are operating efficiently. TRUE ☐ FALSE ☐ NOTES: _____	☐ Open air vents and bleed off air until water appears. ☐ Repair or replace faulty thermostats. ☐ Check pneumatic lines for proper functioning. ☐ Replace faulty valves. ☐ Check water pumps for proper operation. Make necessary adjustments. ☐ Check boiler for correct operating temperature. Correct as required. ☐ Remove objects which may be obstructing heating units.	☐ Clean heating elements.

IV. MECHANICAL SYSTEMS

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. A quantity of outdoor air which does not exceed code requirements is used to ventilate the building.	☐ Reduce outdoor air quantity to the minimum allowed by codes by adjusting appropriate dampers.	☐ Replace defective or damaged dampers with new opposed-blade models.
	☐ Be sure that outdoor air dampers are closed when building is unoccupied.	☐ Install automatic controls to close dampers when building is unoccupied.
TRUE ☐ FALSE ☐	☐ Check all outdoor dampers for defective seals and for proper closure. Repair, if needed.	
NOTES: _____	☐ Place pegboard over the outside of the fresh air inlet.	

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. The ventilation systems are programmed to use natural cooling whenever possible.	☐ Utilize outside air for cooling rather than refrigeration units whenever possible.	☐ Install an economizer cycle with enthalpy control.
TRUE ☐ FALSE ☐	☐ Be sure the economizer cycle is operating properly.	
NOTES: _____		

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. The building's exhaust system functions in accordance with occupancy patterns. TRUE ☐ FALSE ☐ NOTES: _____	☐ Disconnect unnecessary exhaust fans and cover grill to prevent conditioned air loss. ☐ Re-wire special exhaust fans to operate only when room is occupied. ☐ Schedule all other exhaust fans to operate only when needed. ☐ Program exhaust fans with time clocks or other controls.	☐ Install variable speed motors (when replacing exhaust fans) to modulate fan speed, allowing only required ventilation. ☐ Modify all exterior exhaust ducts with controlled or gravity dampers.

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Return, outdoor air and exhaust dampers are sequencing properly. TRUE ☐ FALSE ☐ NOTES: _____	☐ Check damper linkage. Adjust for proper closure. ☐ Readjust indicators to indicate damper positions.	☐ Replace defective or damaged damper with new opposed-blade models.

IV. MECHANICAL SYSTEMS

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Temperature of the air entering through the ducts during the heating season feels comfortably warm. TRUE ☐ FALSE ☐	☐ Reduce air volume to eliminate "draft effect". ☐ Raise supply temperature to 65°F in perimeter zones (60°F in interior zones) during heating season only.	None practical

NOTES: _____

VENTILATION INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#6. The air flow is well-balanced and consistent throughout the building. TRUE ☐ FALSE ☐	☐ Check air filters. Clean or replace regularly. ☐ Remove objects obstructing air flow; clean diffusers, registers and grilles. ☐ Balance air flow system, if required.	None practical

NOTES: _____

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Thermostat settings accurately reflect room temperatures.	☐ Restrict outdoor air intake when not using economizer cycle.	☐ Investigate new types of thermostatic control devices for application in specific situations. Install suitable type.
TRUE ☐ FALSE ☐	☐ Insure that control dampers and valves (especially the economizer cycle) are working properly.	
NOTES: _____	☐ Calibrate thermostats and controllers.	
	☐ Clean thermostatic controls.	

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Zone temperatures are maintained without the use of reheat coils.	☐ Determine if temperatures remain in comfort zone when boilers are shut down during cooling.	☐ Convert to variable air volume system, if practical.
TRUE ☐ FALSE ☐		
NOTES: _____		

IV. MECHANICAL SYSTEMS

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Multiple air conditioning compressors have been modified to prevent simultaneous start-up.	☐ Adjust compressor controls so that unit #2 will not start-up until unit #1 can no longer satisfy cooling demand.	☐ Install automatic staging controls, if needed.

TRUE ☐ FALSE ☐

NOTES: _____

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Insulation on cooling lines, pipes and ducts has been inspected, is adequate and is in good condition.	☐ Replace damaged or missing insulation.	☐ Install additional insulation on all delivery lines and ducts in accordance with good energy conservation practices.

TRUE ☐ FALSE ☐

NOTES: _____

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#5. Cool air in adequate volume is discharged into space. TRUE # FALSE ☐ NOTES: _____	☐ Clean condensor and evaporator coils, fins and tubes. Remove if necessary. ☐ Clean or replace air filters. ☐ Ensure that fire and balancing dampers are open and in correct positions. ☐ Verify that fan is rotating in proper direction.	None practical

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#6. Refrigerated air is at recommended temperature levels. TRUE ☐ FALSE ☐ NOTES: _____	☐ Remove and clean the strainer if frost or sweat is visible at the strainer outlet. ☐ Inspect and clean all coils (including dehumidification coils) regularly. ☐ Clean dirty condensers. Dirty condensors increase system pressure, causing a decrease in system efficiency. ☐ Repair or adjust defective compressor valves. These can be identified by high discharge temperatures.	None practical.

IV. MECHANICAL SYSTEMS

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#7. Evidence indicates that chilled water piping, valves and fittings are intact.	☐ Repair all leaks. ☐ Check valves and fittings. Replace as required.	None practical.

TRUE ☐ FALSE ☐

NOTES: _____

AIR CONDITIONING INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#8. Refrigeration compressor is operating efficiently. TRUE ☐ FALSE ☐ NOTES: _____	☐ Check refrigerant charge level. Adjust to equipment specifications. Repair leaks. ☐ Check for faulty or fused electrical control circuits. Repair or replace as required. ☐ Ensure that liquid line solenoid valve is not leaking or stuck open. ☐ Inspect all compressor valves. Take corrective action if needed. ☐ Clean evaporation and condensor coils. Clean liquid line strainer if clogged. ☐ Reset high/low pressure control differential settings if needed.	None practical.

V. SPECIAL SYSTEMS

WATER INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Hot water storage tanks, piping and heaters are operating efficiently. TRUE ☐ FALSE ☐ NOTES: _____	☐ Reset heater thermostat to 105°F-115°F or to local code requirement. This may require installing a "booster" for the kitchen. ☐ Turn off recirculating pump(s) when building is unoccupied. ☐ Repair all leaks. ☐ Replace damaged or missing insulation.	☐ Install adequate insulation on all lines and tanks containing hot water. ☐ Consider installing smaller domestic water heaters to maintain desired temperature in storage tanks. ☐ Install separate gas fired water heater for use in cafeteria and kitchen.

WATER INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Heating cycle on electric water heater is restricted to low electrical demand periods. TRUE ☐ FALSE ☐ NOTES: _____	☐ Utilize heater's "vacation cycle" during extended vacation periods. ☐ Use a time clock or automatic controls to restrict the duty cycle.	None practical

WATER INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Devices which restrict hot water usage have been utilized. TRUE ☐ FALSE ☐ NOTES: _____	☐ Install inexpensive flow restrictors in lines or faucets.	☐ Install mixing valves that predetermine water temperature. ☐ Re-plumb locker room showers to include a master valve to control shower time. ☐ Replace standard faucets with spring-loaded shut-off types. ☐ Consider installing, if practical, a solar water heater to assist in meeting hot water needs.

WATER INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#4. Swimming pool is energy efficient. TRUE ☐ FALSE ☐ NOTES: _____	☐ Maintain water temperature in maximum range of 80°F-84°F. ☐ Clean filters as required. ☐ Ensure that pool heating equipment is maintained regularly. ☐ Use a flue gas analysis to maintain proper air-to-fuel ratio. ☐ Experiment with ventilation/exhaust system to attain minimum air displacement and still meet code. ☐ Use a buoyant plastic sheet to cover water when not in use.	☐ Consider installing enclosure on outdoor pools. ☐ Investigate solar water heaters to maintain pool temperature.

VI. SPECIAL SYSTEMS

KITCHEN CAFETERIA INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Exhaust hoods and fans operate efficiently and only when needed.	☐ Program operating of exhaust fan. ☐ Ensure that fans and hoods are properly sized to prevent excessive ventilation of other areas of building. Reduce fan speed if necessary.	☐ Investigate heat recovery options of exhausted air.

TRUE ☐ FALSE ☐

NOTES: _____

KITCHEN CAFETERIA INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#2. Food preparation equipment is used wisely.	☐ Turn on electrical equipment only when needed; keep it off when not required. ☐ Clean refrigeration coils regularly. Be sure coils have sufficient air circulation space. ☐ Move refrigerator and/or freezer away from any heat source. ☐ Check (and replace, as required) gaskets on refrigerator, freezer and oven doors for proper seal. ☐ Keep refrigerators full.	☐ Install newer energy efficient models when replacing damaged or defective equipment.

TRUE ☐ FALSE ☐

NOTES: _____

CAFETERIA INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#3. Food service staff is cognizant of good energy conservation techniques. TRUE ☐ FALSE ☐ NOTES: _____	☐ Operate dishwasher only with full-loads. ☐ Train employees to conserve hot water. ☐ Cook with lids in place on pots and kettles. ☐ Thaw frozen foods in refrigerated compartments. ☐ Use fans to cool people not heat sources. ☐ Do not allow refrigerator/freezer doors to remain open. ☐ Avoid preheating ovens. (Studies indicate preheating is unnecessary even for baked goods, if food is allowed to remain in oven several minutes after oven is turned off.)	None practical.

VII. SPECIAL SYSTEMS

LAUNDRY INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Laundry functions are carried out in an energy efficient manner. TRUE ☐ FALSE ☐ NOTES: _____	☐ Train staff to keep lint filters in dryers and the exhaust hoods clean. ☐ Reschedule laundry operation to avoid electrical peak demand hours. ☐ Wash and dry full loads only. ☐ Develop concise operating instruction for each piece of equipment. Post Energy Conservation Plaques. ☐ Reduce washing and drying cycles. Studies indicate that accepted washing/drying times are excessive for most items.	☐ Investigate heat recovery options.

OFFICE MACHINES ELECTRICAL EQUIPMENT INDICATOR	LOWER COST CORRECTIONS (O & M's)	HIGHER COST CORRECTIONS (ECM's)
#1. Operation of electrical devices is carefully monitored.	☐ Turn on office machines only when needed, e.g., copiers, coffee urns, typewriters.	☐ Install a demand limiter to prevent excessive electrical load.
TRUE ☐ FALSE ☐	☐ Use special high-demand equipment such as kilns and electric welders in low demand periods.	

NOTES: _____

ENERGY REPORT FORMS

The following pages are reporting forms, designed in compliance with requirements of DOE rule-making of April 2, 1979. It is recommended that this section be completed by school personnel and/or a qualified state energy auditor.

The following elements are included:

1. Auditor Certification
2. Schoolhouse Energy Usage Forms
3. The Energy Data Collection Forms
4. Evaluation of Potential for Energy Conservation Measures
5. Evaluation of Potential for Solar and Renewable Resource Measures

Special instructions are included to clarify information elements and to facilitate completion of the report. Please note that building implementation of recommendations for changes in operating and maintenance procedures is required in order to qualify for technical assistance/energy conservation measures grants.

NOTE: These forms may be required by your state energy office. Check with the State's director of the Institutional Building Energy Grants Program.

AUDITOR CERTIFICATION

1. I, _____ , am qualified to perform energy audits by:
(print)

☐ successful completion of State training course of

_____ .
(date)

☐ training and experience equivalent to successful completion of State training course:

_____
(detail or date of State waiver of requirement)

2. I am employed to operate this building. ☐ yes ☐ no

3. My financial interests in connection with this energy audit are:
   ☐ no outside interests
   ☐ own, have stock in, or employed by
      ☐ a consulting firm
      ☐ an equipment manufacturer
      ☐ an energy supplier

4. The audit has been conducted in conformance with the requirement of the State of _____ and 10 CFR Part 450, Subpart E.

_____ _____
(Signature) (Date)

Select a year which you consider energy usage to have been reasonable and normal. For purposes of this audit the year selected will be known as your "base year".

Using utility bills from your base year and from the most recent months of the current year, complete the following forms. If your bills use units other than those specified on the forms, use the conversion factors listed below to obtain the desired units.

Heating and cooling degree days can be obtained from your utility or your local weather bureau.

CONVERSION FACTORS

To Change From:	To:	Multiply By:
Electricity:		
Kilowatt Hours (KWH)	Btu's	3,413+/11,600#
Watts	Kilowatts	.001
Natural Gas:		
Thousands of Cubic Feet (MCF)	Cubic Feet	1,000
Hundreds of Cubic Feet (CCF)	Btu's	103,000
Therms	Btu's	100,000
Oil:		
Gallons of #2	Btu's	138,690
Gallons of #6	Btu's	149,690
Propane:		
Gallons	Btu's	95,475
Coal:		
Short tons	Btu's	24,500,000
Purchased Steam:		
Pounds	Btu's	1000+/1390#

+ School Conversion Factor
# Point of Generation Conversion Factor (for federal reporting)

NATURAL GAS

	A		B		C		D		E		F		G	
Month	Reading Date		Gas Used CCF		Gas Cost		Gas Cost Adjustment		Total Cost (C + D = E)		$/CCF (E ÷ B = F)		Heating Degree Days	
	FROM	TO	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE
Jan														
Feb														
Mar														
Apr														
May														
Jun														
Jul														
Aug														
Sep														
Oct														
Nov														
Dec														

TOTAL		
BTU Conversion Factor	x 103,000	x 103,000
Total BTU's		

NATURAL GAS _____ CCF/YR. Current Year _____

Natural Gas Rate No. _____ Base Year _____

Building _____

	A		B		C		D		E		F		G	
Month	Reading Date		KWH Used		Measured Demand KW		$ Cost		(FCA) Fuel Cost Adjustment ($)		Total Cost (D + E = F)		$/KWH (F ÷ B = G)	
	FROM	TO	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE
Jan														
Feb														
Mar														
Apr														
May														
Jun														
Jul														
Aug														
Sep														
Oct														
Nov														
Dec														
Column B Totals														
On-Site BTU Conversion Factor			x 3,413	x 3,413										
Total BTU's														
Column B Totals														
Point of Generation BTU Conversion Factor			x 11,600	x 11,600										
Total BTU's														

ELECTRICITY _____ KWH/YR. Current Year _____

Electricity Rate No _____ Base Year _____

Building _____

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OIL/PROPANE

	A		B		C		D		E		F	
Month	Reading Date		Fuel Used (Gallons)		$ Cost		$/Gallon (C÷B=D)		Heating Degree Days		Fuel Used Per Degree Day (B÷E=F)	
	FROM	TO	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE
Jan												
Feb												
Mar												
Apr												
May												
Jun												
Jul												
Aug												
Sep												
Oct												
Nov												
Dec												
TOTAL												

Conversion Factor:		
#2 Oil	x 138,690	x 138,690
#6 Oil	x 149,690	x 149,690
Propane	x 95,475	x 95,475
Other	x	x
Total BTU's		

OIL ☐ #2 Oil ☐ #6 Oil _____ Gal./Yr.
PROPANE _____ Gal./Yr. Other _____ Gal./Yr.

CURRENT YEAR _____ BASE YEAR _____

	A		B		C		D		E		F	
Month	Reading Date		Steam Used (1,000 of lbs.)		$ Cost		$ per 1,000 lbs. (C÷B=D)		Heating Degree Days		Fuel Used Per Degree Day (B÷E=F)	
	FROM	TO	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE
Jan												
Feb												
Mar												
Apr												
May												
Jun												
Jul												
Aug												
Sep												
Oct												
Nov												
Dec												
Column B Totals												
On-Site BTU Conversion Factor			x 1,000	x 1,000								
Total BTU's												
Column B Totals												
Point of Generation BTU Conversion Factor			x 1,390	x 1,390								
Total BTU's												

STEAM _____ LBS./YRS.

CURRENT YEAR _____

BASE YEAR _____

ENERGY DATA COLLECTION FORMS

This section organizes important school data according to the following categories:

A. General Administrative Information
B. Human Systems
C. Structural Systems
D. Energy Systems
   a. Lighting
   b. Mechanical Systems
   c. Special Systems
E. Energy Consumption Summary
F. Solar and Renewable Resources

Much of this information may be required later by your state energy office in your application for technical assistance. Should technical questions arise concerning mechanical equipment in operation in your school building, consult your engineer or the appropriate service company.

GENERAL ADMINISTRATIVE INFORMATION

1-2. Indicate if single building or complex, enter the name, check the appropriate ownership and category.
3-4. Provide building address (do not use P.O. Box number — enter street address) and phone number. Note year constructed and date of last major addition or modification.
5. Record names and telephones of principal/manager and head custodian/operator.
6. Indicate whether an energy management coordinator has been designated.
7. Indicate whether major changes are anticipated in the facility proper or in its function for the next fifteen years; e.g., new construction, rehabilitation or demolition.
8. Indicate whether any other energy audit has been completed or is currently underway.
9. Describe any conservation measures which have been implemented or are being considered. Indicate expected cost and energy savings expressed as an annual percentage reduction in the type of fuel affected. Attach additional page if necessary.
10. Describe any previous architectural/engineering studies.

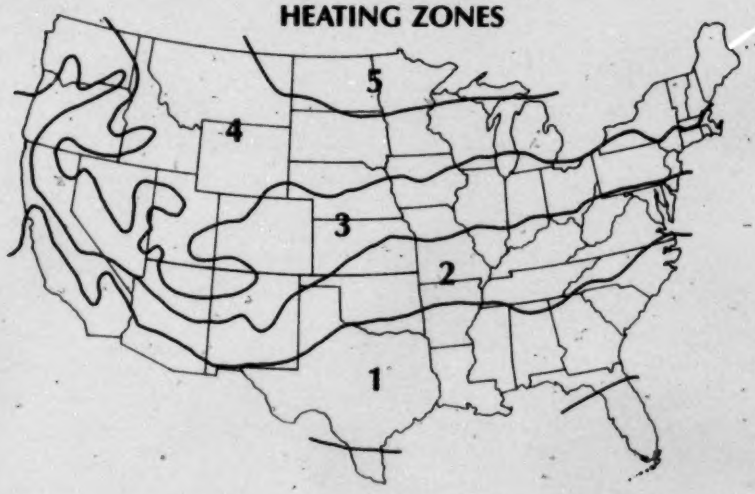
A. GENERAL ADMINISTRATIVE INFORMATION

1. Name of Building or Complex: _____
   Owner: _____
   Public _____ Private _____
   Non-Profit _____ Indian Tribe _____
2. Building Category:
   - ☐ Elementary
   - ☐ Secondary
   - ☐ Junior College
   - ☐ College or Univ.
   - ☐ Vocational
   - ☐ LEA Admin.
   - ☐ Other, Specify _____
3. Building Address: _____ City _____
   State _____ Zip _____ Telephone Number _____
4. Year constructed: _____ Year of last major addition or modification: _____
5. Principal/Manager: _____ Telephone Number: _____
   Head Custodian/Operator: _____ Telephone Number: _____
6. Energy Management Coordinator designated: ☐ Yes ☐ No
7. Anticipated building modifications: _____
8. Previous energy audit completed: ☐ Yes ☐ No Specify, _____
9. Conservation Measures (retrofit) already implemented or under consideration:
   Yes No Specify project, cost and expected energy savings: _____
10. Previous architectural/engineering studies: ☐ Yes ☐ No Specify: _____

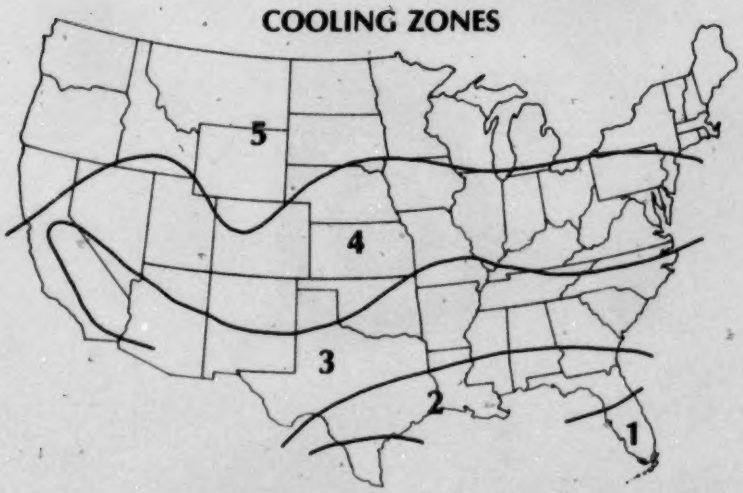
B. HUMAN SYSTEMS

1. Complete occupancy schedule. If the school operates on a seasonal schedule, or has other periods of at least a week's duration when the building is only partially occupied, the number of weeks partial use by calendar quarter should be entered, along with the approximate percentage of total gross square feet in use during such periods.
2. Note U.S. heating and cooling zone in which building is located (see maps below) and climate information unique to your location. Call your utility or local weather bureau.

HEATING ZONES



COOLING ZONES



Day(s)	Time Period	Average Occupancy	or	% gsf Occupied	No. of Hours	Weeks/Year
Mon-Fri	day					
	evening					
	night					
Saturday	day					
	evening					
	night					
Sunday	day					
	evening					
	night					

Quarterly Partial Usage:

Quarter	Weeks	% Gross Square Feet (gsf)
1st		
2nd		
3rd		
4th		

2. Building Location:

U.S. Heating Zone # _____ U.S. Cooling Zone # _____

Annual Heating Degree Days _____ Annual Cooling Degree Days _____
(Base 65°F)

C. STRUCTURAL SYSTEMS

1. To calculate gross square feet (gsf) multiply the outside dimensions or measure from the centerline of common walls and multiply by the number of floors. If the building has wings, or the number of floors varies in one part from another, divide the building into sections, calculate the area of each section, and total. (Deduct from the total area any parking garages or other areas which are neither heated nor cooled.)

2-3. Note type and thickness of insulation material in roof, walls and floors. Note if there is none.

4. Sketch position of facility on site.

5. Briefly describe general building conditions. Indicate any structural flaws or deterioration, if applicable. If building is in good condition, so state.

1. Gross Floor Area: _____ Gross Sq. Ft.
2. Insulation Type: Roof _____ Wall _____ Floor _____
3. Insulation Thickness: Roof _____ Wall _____ Floor _____
4. What is orientation of building on site? (Draw sketch.)

5. Description of general building conditions:

_____

_____

_____

A. Lighting

1-2. For each lighting type, fluorescent and incandescent, note the percentage of gross square feet of the building illuminated. Include an estimate of average usage in hours per week and hours per year.

3. Determine the total wattage presently used to illuminate the building's interior and divide by the gross floor area to compute an average lighting level in watts per square foot.

4. Indicate potential for lower lighting levels: classrooms, corridors, offices, gymnasium(s), auditorium(s), library, cafeteria, shops, others.

1. Fluorescent:
   Percentage of Gross Sq.Ft: _____ % Usage: _____ Hr/Wk _____ Hr/Yr
2. Incandescent:
   Percentage of Gross Sq.Ft: _____ % Usage: _____ Hr/Wk _____ Hr/Yr
3. Average Interior Lighting Level: _____ Watts/SqFt
4. Potential for lower lighting levels (check box if yes):

☐ Classrooms	☐ Auditoriums	☐ Other (Specify)
☐ Corridors	☐ Library	_____
☐ Offices	☐ Cafeteria	_____
☐ Gymnasiums	☐ Shop(s)	

D. ENERGY SYSTEMS

B. Mechanical

1-10. Check the type and capacity of HVAC systems found in your school. If knowledge of the system is not available, obtain the information from the mechanical engineer, blueprints, specifications or nameplates. Total the cubic feet per minute (CFM) of air that the air systems supply to the building. Note what percentage of outside air is used. Note the heating and cooling capacities and fan horsepower.

11. Note the principal fuels used by the heating and cooling systems.

12-13. Larger buildings tend to have boilers or purchase hot water or steam. Small buildings tend to have unitary direct fired equipment. Determine your system type. Estimate the number of hours per day that the heating plant operates during winter. Examine the cooling equipment to determine system(s) type. Estimate the number of hours per day that the cooling system(s) operates during summer.

System Type	Total CFM	Minimum % Outside Air	Capacity BTU/hr	Fan Horsepower
1. Terminal Reheat				
2. Multizone				
3. Dual duct				
4. Variable Air Volume				
5. Induction				
6. Fan Coil	N/A			
7. Heat Pump				
8. Air Exhaust		N/A	N/A	
9. Radiation	N/A	N/A		N/A
10. Other (Specify) _____				

11. Heating System

_____
Fuel Type

12. Systems Types: (Check √)
- ____ Boilers
- ____ Purchased water or steam
- ____ Unitary Direct Fired
- ____ Furnaces
- ____ Package Equipment

13. Operation Profile:
- ____ hrs/weekday
- ____ hrs/Saturday
- ____ hrs/Sunday

Cooling System

_____
Fuel Type

System Types: (Check √)
- ____ Absorption
- ____ Electric Drive
- ____ Steam Turbine Drive
- ____ Water Cooled Packaged Unit
- ____ Air Cooled Packaged Unit

Operation Profile:
- ____ hrs/weekday
- ____ hrs/Saturday
- ____ hrs/Sunday

C. Special Systems

1. Indicate water heating source.
2. Complete data for swimming pool, if applicable.
3. Are laundry services provided? Enter fuel type.
4. Are food services provided?
5. List type and number of office equipment.
6. List kind and wattage of special high electrical demand equipment; e.g., kilns, electric welders.

1. Domestic Water Heated By: Electricity _____ Natural Gas _____
   Other _____
   (Specify)
2. Swimming Pool:
   ☐ Indoor ☐ Outdoor
   Heating Fuel: _____
   Normal Water Temperature: _____ °F
3. Laundry Services ☐ Yes ☐ No
   Fuel Type: Washers _____ Dryers _____
4. Food Services ☐ Yes ☐ No
   Major cooking fuel: _____
5. Office Machines (kind and number of each)

   _____ #_____

   _____ #_____

   _____ #_____

   _____ #_____

6. High Demand Electrical Equipment (kind and wattage)

   _____ _____ watts

   _____ _____ watts

   _____ _____ watts

   _____ _____ watts

E. ENERGY CONSUMPTION SUMMARY

1. Complete fuel use summary for base year (or last 12 months if no base year has been established), using utility records and Energy Usage Forms in Section 2. (If no past records have been kept, call your utility.) Multiply by the conversion factors (as required by the *Federal Register,* Section 450.42(11), April 2, 1979) and enter the results in Column D as annual BTU consumption.

   Transfer annual cost for each fuel from the appropriate Energy Usage Form to Column E.

   Compute consumption in BTU's per gross square foot per year by dividing the total of the entries in Column D by (C-1) gross square feet.

   Compute energy dollars per gross square foot per year by dividing the total of the entries in Column E by gsf. (Obtain gross floor area from previous chart (C-1) and energy costs from Energy Usage Forms.)

   Notes: • No. 2 oil should include other distillate fuel oils.
   • No. 6 oil should include other residual fuel oils.
   • Use a standard engineering manual or conversion factors provided by the State for other fuels (Row 8, Column C).

2. Based on your past year's utility bills, complete peak electrical demand data. For buildings or complexes over 200,000 gsf or if the electric rate contains a demand charge, determine if demand is recorded. Note times at which typical peaks occur during daily operation. Also note whether demand fluctuates on a seasonal basis, indicating month in which the highest demand occurs.

3. *If data is available,* indicate the fuel used by each of the major energy using systems listed and the annual consumption of each. For #5 "special", indicate special purpose facilities (e.g., food service, laundry) which use significant amounts of energy, fuel type used and annual usage.

E. ENERGY CONSUMPTION SUMMARY

A	B	C	D	E	F	G
Fuel	**Previous 12 Month Totals**	**Conversion Factor**	**BTU's Consumed**	**Annual Cost**	**BTU's/Gross SqFt/Year**	**S/Gross SqFt/Yr**
1. Electricity	KWH x	11,600 =				
2. Natural Gas	CCF x	103,000 =				
3. #2 Oil	gallons x	138,690 =				
4. #6 Oil	gallons x	149,690 =				
5. Steam	pounds x	1,390 =				
6. Coal	tons x	24,500,000 =				
7. Propane	gallons x	95,475 =				
8. Other, Specify	x	=				
9. TOTALS	N/A	N/A				

2. Peak Electrical demand:

Daily: _____KW
Time: _____

Annual: _____ KW
Month: _____

3. Fuel Use by Major Energy-Using Systems:

SYSTEM	FUEL TYPE	ANNUAL USE
Heating		
Cooling		
Hot Water		
Lighting		
Special, specify		

F. SOLAR AND RENEWABLE RESOURCE POTENTIAL

1. Check characteristics of adjacent property.
2. Indicate nature of location.
3. Indicate building shape as square, rectangular, E-shaped, H-shaped, L-shaped or attach a rough sketch of the configuration. Note whether roof and southern wall are shaded or unshaded.
4. Note roof design. For the orientation of a pitched roof, indicate the *compass direction* of a line perpendicular to the ridgeline in the direction of the down slope. Note presence of roof obstructions such as chimneys, space conditioning equipment, water towers, mechanical rooms and stairwells. Identify the principal structural material of the roof; e.g., steel, concrete, or wood structural components. Also identify the type of roofing such as shingle, slate or built-up.
5. Indicate structure composition of southern facing wall. Determine percentage of wall area covered by glass.
6. Check type and location of space and water heating equipment.
7. Using information from the National Weather Service or your State's energy office enter monthly average solar insolation and wind speeds.
8. Note any special conditions or characteristics related to potential for solar or other renewable resource application.

F. SOLAR AND RENEWABLE RESOURCE POTENTIAL

1. Adjacent open land:

☐ Field ☐ Yard ☐ Parking Lot ☐ Other, specify _____

Is the adjacent land: ☐ Heavily shaded ☐ Not heavily shaded

2. Location:

☐ Urban ☐ Suburban ☐ Rural

3. Building characteristics:

Building shape _____

☐ Roof Unshaded ☐ Southern Wall Unshaded

Number of Stories _____

4. Roof Design:

☐ Flat ☐ Pitched; Orientation _____ Primary Structural Material _____ Type of Roofing _____

5. Composition of Southern Facing Wall: _____

_____

Southern Facing Wall Glass Area:

☐ Less than 25% ☐ 25% to 75% ☐ over 75%

6. Type and location of space heating equipment:

☐ Single Unit ☐ Multiple Units

☐ Outside, Location: _____

☐ Inside, Location: _____

7. Average Insolation

Average Insolation (BTU's/SqFt/Year)

Jan _____ April _____ July _____ Oct _____

Feb _____ May _____ Aug _____ Nov _____

Mar _____ June _____ Sept _____ Dec _____

Average Wind Speed:

Average Wind Speed (miles/hour)

Jan _____ April _____ July _____ Oct _____

Feb _____ May _____ Aug _____ Nov _____

Mar _____ June _____ Sept _____ Dec _____

8. Special conditions

_____

_____

EVALUATION OF POTENTIAL FOR ENERGY CONSERVATION MEASURES

The Department of Energy has developed a Relative Importance Factor (RIF) for the five items listed: The RIF, ranging from 15 to 35 is assigned to each of the five items. Within each item, conditions are described and a Weighting Factor (WF) assigned to each condition. The evaluation of the potential of the building for energy conservation measures is based on the sum of the products of the RIF's and WF's. The higher this combined value, the greater the potential for energy savings. Determine the Weighting Factor as follows:

A. HVAC System Type (RIF: 35)

Note the type of HVAC system found in your building.

	WF
☐ Reheat or Dual Duct	1.0
☐ Multizone or Induction Units	.9
☐ Rooftop Units, Wall Units, or Unit Ventilators	.8
☐ Fancoil, VAV, or Heat and Vent System	.7
☐ Radiation, Unit Heaters (no fan systems)	.6

B. Outside Air (RIF:20)

Note the amount of outside air introduced through your ventilation systems. Check the ventilation system for outside air percentage.

	WF
☐ 76 to 100% Outside Air	1.0
☐ 51 to 75% Outside Air	.9
☐ 26 to 50% Outside Air	.8
☐ 10 to 25% Outside Air	.7
☐ Infiltration, toilet exhausts only	.6

C. Building Envelope (RIF:15)

Percentage of glass area can be estimated by dividing the glass area in a typical wall by the total wall area. The degree of infiltration can be determined by noting how tight-fitting the outside doors and windows are in their frames; i.e., tight fitting doors and windows, low infiltration; loose fitting, high infiltration.

	WF
☐ Bldgs over 40% glass and large infiltration	1.0
☐ Bldgs over 40% glass	.9
☐ Bldgs with large infiltration	.8
☐ Bldgs under 40% glass	.7
☐ Bldgs with low infiltration	.6
☐ Bldgs under 15% glass	.5

D. Lighting (RIF:15)

Add the wattage of all lamps in the building and divide by the gross floor area of the building.

	WF
☐ Lighting over 3 watts/SqFt	1.0
☐ Lighting 2 to 3 watts/SqFt	.9
☐ Lighting 1 to 2 watts/SqFt	.8
☐ Lighting reduced by changes in switching	.7
☐ Lighting levels that cannot be reduced	.6

E. Fan Energy (RIF:15)

To determine square feet per fan horsepower (HP), divide building gross floor area by total HP of all HVAC and ventilating fans in the building. HP rating can be found on nameplates of pumps and motors in your air handling systems.

	WF
☐ Under 200 SqFt per fan HP	1.0
☐ 200-600 SqFt per fan HP	.9
☐ 601-1000 SqFt per fan HP	.8
☐ 1001-1500 SqFt per fan HP	.7
☐ 1501-2000 SqFt per fan HP	.6
☐ Over 2000 SqFt per fan HP	.5

Complete the following table to determine the energy conservation measure potential index:

	RIF	x WF =	EVALUATION
a. HVAC System Type	35		
b. Ratio Outside Air	20		
c. Bldg. Envelope — % Glass and Infiltration	15		
d. Lighting Levels	15		
e. Fan Energy	15		
Energy conservation measure potential index:			

EVALUATION OF POTENTIAL FOR SOLAR AND RENEWABLE RESOURCE MEASURES

This evaluation is to be completed in the same manner as the Energy Conservation Measures Evaluation in the previous section.

A. Available Insolation (RIF:30)

Available insolation is a function of geographic location and site characteristics. Determine average annual horizontal insolation on a horizontal surface from information provided by the State or from the National Weather Service data for your location. Observe whether the building is shaded or unshaded (a building whose roof and south-facing wall are approximately more than half-shaded for more than approximately four hours per day — should be considered "shaded".) If the building itself is shaded, note whether there is open, unshaded land available adjacent to the building site.

	WF
☐ Unshaded and 1300 BTU/SqFt or more	1.0
☐ Unshaded, less than 1300 BTU/SqFt	.5
☐ Open land and 1300 BTU/SqFt or more	1.0
☐ Open land, less than 1300 BTU/SqFt	.5
☐ Shaded, 1300 BTU/SqFt or more	.2
☐ Shaded, less than 1300 BTU/SqFt	.1

B. Wind Speed (RIF:30)

Determine average monthy wind speed, using data supplied by the State, obtained from the National Weather Service or local records. Note whether there are natural or man-made barriers in the direction of prevailing winds.

	WF
☐ Greater than 15 mph, no obstructions	1.0
☐ Between 10-15 mph, no obstructions	.5
☐ Greater than 15 mph, some obstructions	.7
☐ Between 10-15 mph, some obstructions	.3
☐ Less than 10 mph	.2

C. Fuel Used (RIF:20)

Note the fuel used for space and water heating

	WF
☐ All electric	1.0
☐ Oil or gas heat	.8
☐ Coal heat	.4
☐ Oil or gas heat, hot water	.4
☐ Coal heat, hot water	.2

D. Wall Characteristics (RIF:20)

Determine the glass area of the south-facing walls as a percentage of the total wall area, noting the construction material.

	WF
☐ Over 75% glass; masonry	1.0
☐ Over 75% glass; aluminum or metal	.7
☐ Over 75% glass; wood or other material	.6
☐ 25%-75% glass; masonry	.7
☐ 25%-75 glass; aluminum or metal	.6
☐ 25%-75% glass; wood or other material	.4
☐ Under 25% glass; masonry	.5
☐ Under 25% glass; aluminum or metal	.3
☐ Under 25% glass; wood or other material	.2

E. Building Characteristics (RIF:10)

A "favorable" building is one which is compact (i.e., square or rectangular), in which the equipment is in one location on the roof or adjacent to the south-facing wall.

A building which is "fair" would be other than compact (i.e., E-shaped, L-shaped, etc.) but in which the equipment is in one location on the roof or adjacent to the south-facing wall, or a building which is compact but in which the equipment is within 5 floors of the roof or 50 feet of the south-facing wall.

A building which is not compact and in which the equipment is located beyond five floors of the roof and 50 feet of the south-facing wall is to be characterized as "moderate".

A high irregular building or one in which equipment is in scattered location — most of which are more than five floors from the roof or 50 feet from the south-facing wall — is characterized as "poor".

	WF
☐ Favorable	1.0
☐ Fair	.8
☐ Moderate	.5
☐ Poor	.2

EVALUATION OF POTENTIAL FOR SOLAR AND RENEWABLE RESOURCE MEASURES

F. Roof Characteristics (RIF:10)

Characterize the building as "favorable" if the roof is flat or pitched nearly to the south, if the roofing is built-up, shingled or otherwise sufficiently durable to withstand mounting and maintaining solar collectors, if the structural members are strong enough to support additional weight and the roof area is free of obstructions.

A "fair" rating would be given a building meeting the above conditions except that the roof pitch is only approximately in the direction of south or where there are roof obstructions.

Describe a building as "moderate" if the roof pitch is only approximately toward the south and there are roof obstructions.

A building which meets none of these conditions is characterized as "poor".

	WF
☐ Favorable	1.0
☐ Fair	.8
☐ Moderate	.5
☐ Poor	.2

Complete the following table to determine the solar and renewable resources potential index:

	RIF	x WF =	EVALUATION
a. Insolation Available	30		
b. Wind Speed	30		
c. Fuel Used	20		
d. Wall Characteristics	20		
e. Building Characteristics	10		
f. Roof Characteristics	10		
Solar and renewable resource measure potential index:			

Air change	The movement of a volume of air in a given period of time in or out of a building or room. Air changes are expressed in cubic feet per minute.
Air conditioning	The process of treating air so as to simultaneously control its temperature, humidity, cleanliness and distribution with regard to a specific space.
Boiler	A device used to heat water and/or produce steam. Major components include burner, heat exchanger, flue and expansion chamber and controls. Traditional fuels are oil, gas, coal and electricity.
Boiler efficiency	The ability of a unit to convert a form of energy (gas, oil, coal, electricity) to heat at the highest possible rate. Usually, 80-85% efficiency is attainable.
British thermal unit (BTU)	The amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. A unit of thermal (heat) energy approximately equal to the amount of heat given off by burning a kitchen match.
Building envelope	The physical elements which make up the exterior of a building.
Building orientation	Considered in relation to the site orientation, the direction of prevailing winds and the sun. These relationships directly impact the heat loss/gain properties of a building.
CFM	Cubic feet per minute.
Capacity	The usable output of a system or system component.
Chimney effect	The tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared with that of the surrounding air. In buildings, the tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air due to the difference in density of inside and outside air.
Comfort zone	The ranges of indoor temperature, humidity and air movement under which most persons enjoy mental and physical well-being.
Conduction	A process of heat transfer whereby heat is transmitted through a material.
Convection	Transfer of thermal energy (heat) by the movement of a fluid or gas.
Damper	A device used to vary the volume of air passing through an air outlet, inlet or duct.
Degree day	The difference between 65°F and the average daily temperature, e.g., if the average daily temperature is 25°F, the degree days would be 40 (65 − 25 = 40). The greater the number of heating or cooling degree days, the higher the energy consumption.
DHW	Domestic hot water
Economizer cycle	A method of operating a ventilation system to reduce refrigeration load. Whenever the outdoor air conditions are more favorable (lower heat content) than return air conditions, outdoor air quantity is increased.

GLOSSARY

Energy	The capacity for doing work, taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical. In customary units, measured in kilowatt hours (KWH) or British thermal units (BTU).
Energy audit	Examination of a building's architectural and mechanical drawings, energy usage patterns, and fuel history in order to identify energy conserving opportunities.
Footcandle	Energy of visible light at a distance of one foot from a standard candle.
Flow rate	Velocity at which fluid travels through an opening or duct.
Fenestration	Windows, glazing
Flue gas analysis	A test procedure whereby the relationship between air, fuel and stack temperatures are monitored, indicating the apparent transfer of energy during combustion of the fuel.
Heat gain	As applied to HVAC calculations, it is that amount of heat gained by a space from all sources, including people, lights, machines, sunshine, and furnace.
Heat loss	A decrease in the amount of heat contained in a space, resulting from heat contained in a space, resulting from heat flow through walls, windows, roof and other building envelope components.
HVAC	Heating, ventilating and air conditioning systems.
Infiltration	The process by which outdoor air leaks into a building by natural forces, especially as through cracks around doors and windows.
Kilowatt hour (KWH)	Unit of electrical energy consumption which equals about 3400 BTU's
Life cycle cost	The cost of equipment over its entire life including operating and maintenance costs.
MBTU	One thousand British thermal units.
Masonry	Stone, brick, concrete, hollow tile, concrete block, gypsum block, or other similar building units or materials, or combination of the same, bonded together with mortar to form a wall, piers, buttress, or similar mass.
Operating cost	The cost in money to operate a system for a given period of time. One common use is in the comparison of different systems.
Orsat apparatus	A device for measuring the combustion components of boiler or furnace flue gases.
Payback period	The time required for anticipated energy savings to recover the cost of the investment; also termed recovery rate.
R-value	The resistance to heat flow. The higher the "R" value, the greater the insulating efficiency of the material.
Retrofit	Alteration or modification of an existing structure, or mechanical system or components therein in order to conserve energy.

Set back	The lowering of the thermostat setting. The technique is used to reduce the amount of energy required to heat a space.
Shading device	A covering which blocks the passage of solar radiation. Common shading devices consist of awnings, overhangs, or trees.
Ton of air conditioning	The thermal refrigeration energy required to melt one ton of ice (2,000 pounds). Also a means of expressing cooling capacity. (1 ton = 12,000 BTU/hour cooling)
"U" value	A coefficient which indicates the energy (BTU's) which passes through a unit area of a surface for every degree (Fahrenheit) of temperature difference from one side to the other under steady state conditions.
Ventilation	Air introduced to an occupied space or building to accomplish comfort and odor control. Commonly refers to outside air quantitites mixed with room air.
Weatherstripping	Foam, metal, or rubber strips used to form a seal around windows, doors, or openings to reduce infiltration.

The film, The Fourth R, and a companion booklet are available to school patrons, professional educators and others interested in the quality of our schools and in energy management.

The film may be borrowed without cost by writing:
Tenneco Inc.
Public Affairs Department
P.O. Box 2511
Houston, Texas 77001